Printed on thin paper for overseas circulation.

Engineering Library

The Engineer

MAR 26 1940

VOL. CLXIX.—No. 4391 28, ESSEX ST., STRAND, LONDON, W.C.2 MARCH 8, 1940

Established 1856 Price One Shilling, by Inland Post 1s. 3d. Registered as a Newspaper

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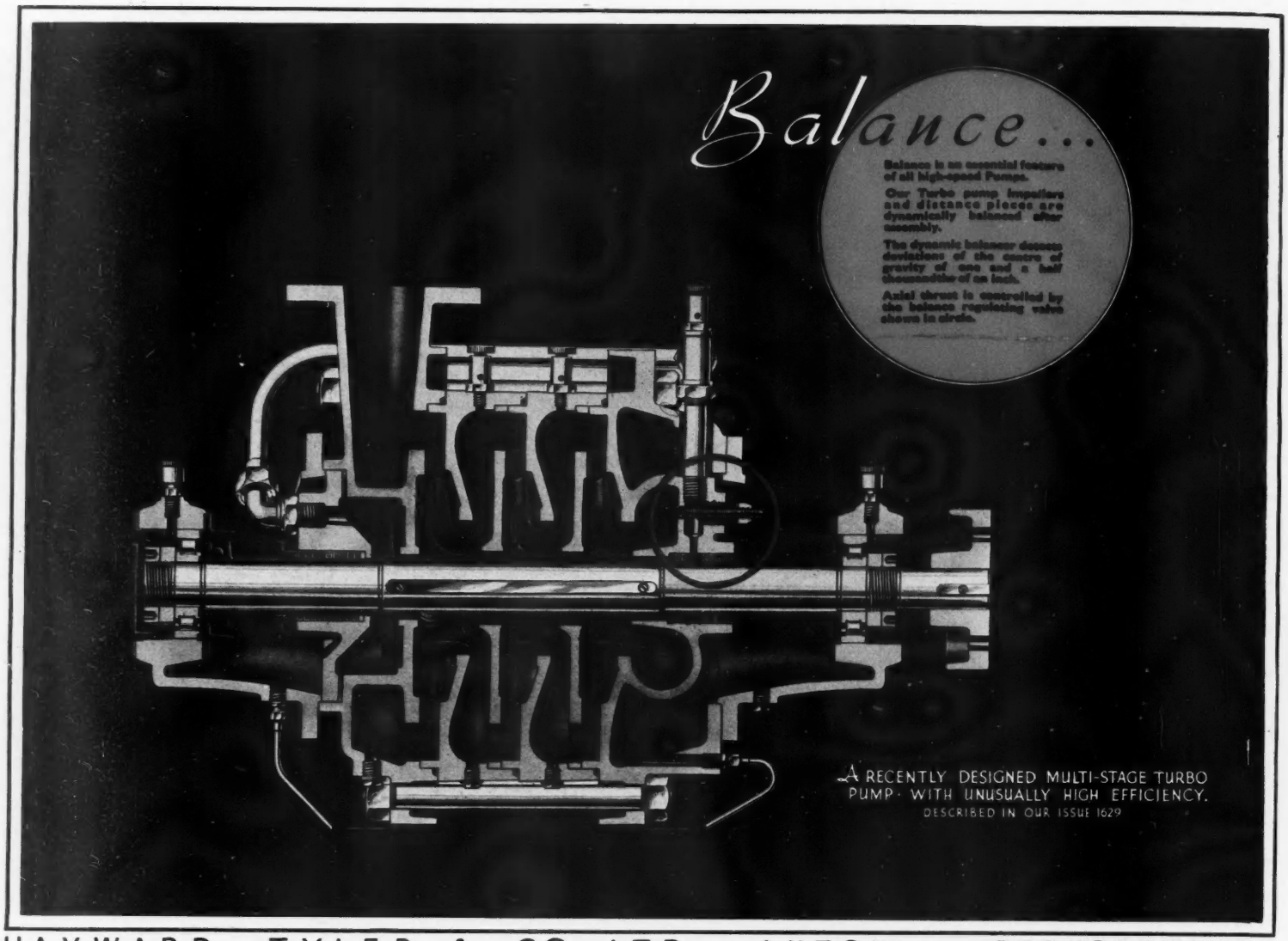
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Machine Tool Trades Association

ON Thursday, February 29th, the Machine Tool Trades Association held a luncheon at Grosvenor House, London. This function took the place of the dinner that the Association usually holds at this time of year. Mr. Harold Butler, President of the Association, took the chair. After the loyal toasts of "The King" and "The President of the French Republic" had been honoured, Mr. Butler proposed the toast of "His Majesty's Government and the success of the Allies." A few of his remarks were made in French in acknowledgment of the prescence of a number of French guests. He mentioned that the Association had, during the previous week, discussed with the French matters affecting the production of machine tools in both countries, and that the French were experiencing the same conditions as it was. One of the troubles was the "labour bottleneck." He assured Mr. Burgin, Minister of Supply, who was the principal guest of the Association, that the members were determined to tackle their problems resolutely. In reply, Mr. Burgin said that the war was one of machines and material. There were 2000 different types of machine tools and 35,000 persons employed in the machine tool trade. Would that the number could be multiplied! To that object their efforts must be directed. He had received a letter from his opposite number in France, M. Dautry, expressing appreciation of the visit of the president of the Association and his colleagues. After referring to the extent of modernisation that was necessary to economise labour, and to the development of machine tools simpler to operate, he thanked the industry for its efforts in that direction. Many countries made machine tools. In terms of cost those from the United States were between 1¾ and 2½ times as expensive as British machines. He assured the Association that the expansion of the industry would make its hold on the home market more secure. Sir Alfred Herbert then proposed the toast of "The President," remarking that, at a meeting held before the lunch, he had consented to retain that position for an unspecified period, probably the duration of the war. He also pointed out that productivity could be greatly increased by working night shifts. It was a sad fact that one half of our machining capacity was lying idle at the present time. Mr. Butler replied in suitable terms.

The Largest American Liners

FURTHER particulars are now available concerning the two liners for the Pacific service between San Francisco and the Orient, for which the United States Maritime Commission has recently invited tenders, which are to be opened on Tuesday, May 17th. The ships, which will be the largest ever built in the United States, it is understood, are to be constructed in such a way that, in an emergency they can be quickly converted into aircraft-carriers. The principal hull dimensions and machinery particulars are as follows: length 759ft., beam on water-line 98·2ft., with a designed displacement of 35,500 tons, and speed of 24 knots. The ships are to be designed for about 1000 passengers, with a personnel of about 500. The space available for cargo is to be about 535,000 bale cubic feet. The hulls are to have a curved raked stem, a cruiser stern, and a long bridge house. There will be five complete steel decks in addition to the promenade, boat, and sun-decks. The subdivision of the hull will include fourteen main watertight transverse bulkheads with additional oil and watertight bulkheads. The passenger quarters arranged on the boat, promenade, main, and "A" to "D" decks, will be in accordance with the latest practice, and will include air conditioning for the cabin and tourist accommodation and the dining-rooms. An efficient fire detection system is to be provided. The propelling machinery will comprise a twin-screw arrangement of triple-expansion turbines with double-reduction gearing, taking steam from modern water-tube boilers. The machinery is to be arranged in two separate compartments, in such a way that damage to one compartment will not necessarily involve the flooding of the other.

The Women's Engineering Society

THE twenty-first anniversary of the foundation of the Women's Engineering Society was celebrated on Monday, March 4th, by a luncheon at the Park Lane Hotel, London, with Miss Caroline Haslett, President of the society, in the chair. In proposing the toast to the society, the Right Hon. Ernest Brown, Minister of Labour and National Service, spoke of the place that women could fill in industry to assist in achieving the country's maximum effort. In the last twenty years, he said, there has been a growing acceptance of women's place in industry, and the demand for their services in various directions was bound to continue. A matter of importance at present was the expansion of the engineering industry to meet war demands and to maintain and increase our export trade, and conversations were proceeding on both sides of the industry on matters of labour and national service. It was not possible at the present stage to anticipate the outcome of those conversations, but the Minister expressed his gratitude for the manner in which both sides of the engineering industry were showing their readiness to tackle the problems of expansion. The Government's programme was a very big one, and it was confidently expected that men and women suitable and available for employment would be required in numbers far in excess of those of the present unemployed. In responding to the toast, Miss Haslett reviewed the growth of the society, and spoke of its endeavours to assist the engineering industries. Other speakers were the Dowager Lady Swaythling, president of the Electrical Association for women, Miss Pauline Gower, and Miss Monica Maurice.

Railway Working in War Time

IN the course of his address at the annual general meeting of the Great Western Railway Company, held on February 28th, the Right Hon. Viscount Horne, chairman of the company, who presided, reviewed the activities of the Great Western system under war time conditions. He suggested that in playing their part in the mechanism of war the stockholders already deserved well of the nation. If the stockholders had insisted upon dividends rather than a high standard of maintenance and renewals, the Government would now have been faced with the necessity of large expenditure—for without efficient railways, the war could not be fought. Happily, it stands, he said, to the credit of the British railways that they compare in efficiency with any other railways in the world, for they had been maintained in a condition which render them adequate to the needs of the nation in war. Referring to the effects of war conditions on the staff, he said that he could not speak too highly of the magnificent efforts made by all grades. Since the war began over 3500 special trains had been run over the system for the conveyance of troops and munitions and in addition there had been large increases in goods traffic. The lighting restrictions seriously reduced the working efficiency at stations, goods sheds, and marshalling yards, in some cases by as much as 30 per cent. After overcoming those initial difficulties considerable improvement in passenger services had been made. He went on to say that in this time of anxiety and uncertainty it would be imprudent to predict anything with regard to the future. But it was possible to mention one factor which—unless the world was entirely changed after the war—would give hope for increased activity on the Great Western Railway. During the last three years there had been 239 new industrial and commercial undertakings established on the system, embracing a large variety of businesses. But nothing would ever be successful or prosperous in this country unless we seized victory from the grim struggle upon which we had entered.

Institution of Structural Engineers

NEARLY four hundred members and guests were present at the annual dinner of the Institution of Structural Engineers which was held in London at the Dorchester Hotel on Friday, March 1st. The toast of the Institution and its president, Mr. Percy J. Black, was proposed by the Parliamentary Secretary to the Ministry of Supply, Colonel J. J. Llewellin, who dealt mainly with the work of his department as concerned with structural engineering. He pointed out that the two principal sides of the Ministry's work were to erect and equip ordnance factories, and to see that the raw materials of industry were adequately provided. In his remarks regarding the second of these, Colonel Llewellin said that an economy committee had been set up to investigate the possibility of any savings which might be made on the various departmental specifications particularly with regard to timber and steel. Factories for the Ministry which had hitherto been built through the Office of Works were now being constructed by private contractors, and the speaker said that the co-operation which existed between the architects and constructional engineers in this work was particularly encouraging. He concluded by saying that, although the present trend of events was more towards destruction than construction, he hoped that the great constructive effort of the Institution would steadily progress. In replying to the toast, Mr. Black said that the dinner, held at such a time, was symbolic of the optimism of the structural engineer, and although the Institution was comparatively young it was very virile. He reminded his listeners that before the war building was one of the most beneficial industries to this country, and it had reached a high level of efficiency owing to the co-operation of all branches. It was one of the few industries which had had but little State subsidy or assistance. In his opinion it was in the public interest that the Government should make an effort to set to work the number of branches at present halted owing to their work not being of immediate national importance, because if the co-operative spirit that had been built up was allowed to break down it would be to the detriment of the country when peace was declared. The health of the guests was proposed by Mr. M. B. Buxton, vice-president of the Institution, and responded to by Sir Clement D. M. Hindley, the president of the Institution of Civil Engineers.

The Unemployment Returns

THE total number of unemployed on the registers on February 12th, 1940, was 1,504,100, made up of 1,141,538 wholly unemployed, 315,072 temporarily stopped, and 47,670 normally in casual employment. There was a drop, relative to the previous month, of 80,145 in the number wholly unemployed and normally in casual employment. But this decrease was largely offset by an increase of 65,349 in the number of those temporarily stopped, being a net reduction of only 14,796. As compared with the previous month there were increases in the number of unemployed in agriculture, coal-mining, building, iron and steel, public works contracting, tinplate manufacture, shipbuilding and repairing. Among the engineering trades, only motor-vehicles, cycles, and aircraft recorded a decrease. When the comparison is made with February 1939, however, it is found that heavy decreases in unemployment are recorded in practically all trades, with the notable exception of building. The increases in the numbers unemployed relative to the previous month can be traced, it is considered almost wholly to the weather conditions at the time when the count was taken. The effect of long continued frost and snow had, of course, a marked effect on outdoor employment and employment in other trades was influenced by the partial dislocation of transport and the consequent difficulty of ensuring deliveries of essential materials. During the fortnight following the date of the count, the continuance of better weather enabled much of the dislocation to be remedied. There was certainly a large drop in the number of unemployed, and the reduction is estimated to amount to about 200,000.

The Financial Basis of Shipping

ON Thursday, February 29th, Sir Philip Haldin, in his presidential address to the annual meeting of the Chamber of Shipping of the United Kingdom, emphasised the need to put British shipping on a sound financial basis now, so that it can accumulate adequate reserves to replace losses and to prepare for intensified competition after the war. He pointed out that a day lost in waiting or in loading or discharge of cargo was a day given to the enemy. The success of the requisition policy, he said, would depend in great measure upon the Government relying on the incentive of the shipowners and on their experience. Satisfactory charter conditions had been secured in the prolonged negotiations with the Government, and he hoped that the industry would secure rates of hire which would be adequate for expenses, a fair return on capital, and something towards reserves. If at the end of the war the industry was left with depleted resources to meet increased foreign competition, there would be no alternative to subsidising it on a scale far in excess of the assistance recently offered. Otherwise our mercantile marine would sink to the level of a third-rate power. The Government's proposed scheme to provide insurance for vessels lost by war casualty was being considered by the industry. The replacement problem, however, was not confined to war losses, which might prove to be the smallest part of it. The essence of the problem was to find means of building new ships for old, of replacing ships lost by marine accident, and of obtaining fresh capital. In support, Lord Essendon stated that the British Shipping Assistance Bill never became law because of the war. The proposal for grants was suspended, but he felt sure that the Government would implement their promise, because it was an undoubted fact that had it not been for those proposals about 1,000,000 gross tons of orders placed last spring would never have been contracted for. That tonnage was now rapidly approaching completion, and would be of the greatest possible value to the country. The cost of building had already increased by 50 per cent. in the last few months, and at the higher cost of replacement the existing depreciation reserves would be hopelessly inadequate. The meeting took place for the first time in the new home of the Chamber, at Bury Court, St. Mary Axe, London, E.C.3. Amongst the resolutions passed was one placing on record the appreciation and thanks of the Chamber to Sir Vernon Thomson for the service he had rendered to the industry in instigating and bringing to a successful completion the building of the Chamber's new home.

Heavy Passenger Engines, South African Railways

By E. C. POULTNEY, M. Inst. Loco. E.

No. I

TO meet a demand for locomotives of greater power, required especially to work the important through passenger services over the main line between Cape Town and Johannesburg, some large 4–8–2 type engines have recently been placed in traffic, built to the designs of Mr. W. A. J. Day, Chief Mechanical Engineer of the South African Railways Administration. Though officially designated as heavy passenger locomotives, they are intended to be equally suitable for handling both passenger and freight trains, and in many respects constitute an outstanding design, both as regards size and potential power output, especially so when the rail gauge of 3ft. 6in. is taken into consideration.

The object of this article* is to describe these remarkable locomotives. Before doing so, however, a brief reference will be made to others of the same general type, introduced during the last few years as part of a programme having for its purpose the provision of powerful locomotives of modern design required to handle the traffic economically, and to take the place of older and smaller engines. For some few years past the S.A. Railway Administration has been giving considerable attention to the improvement of the main lines, and to this end realignment of the track to reduce curvature and also a certain amount of gradient elimination has been undertaken, while at the same time a departmentally designed 96 lb. rail has been adopted as standard in place of the B.S.S. 80 lb. rails formerly employed. This change in conjunction with steel sleepers and adequate and well-maintained ballast has greatly improved the road. With these improvements, heavier and more powerful locomotives have been made possible, resulting in the construction in 1935 of some large 4–8–2 and 4–6–2 main line engines, the former by R. Stephenson and Co., Ltd., Darlington (now Stephenson and Hawthorns, Ltd.), and Henschel und Sohn, Cassel, Germany. Both types represented a considerable advance in size and power over those in general service at that time, and in several features were alike. The cylinders, 24in. by 28in., were common to both, and generally the boilers were the same, except that in the case of the "Pacific" type the length of the barrel section was somewhat shorter. For the eight-coupled design the driving wheels had a diameter of 5ft., while for the 4–6–2 engines the coupled wheels had a diameter of 6ft., the largest ever used on the South African Railways. These locomotives are classified "15 E" and "16 E," and twenty of the former were built and six of the latter. No more of the "Pacifics" were ordered, but a further lot of the class "15 E" were constructed by Henschels, and also by the Berliner Maschinenbau A.G. Vormals L. Schwartzkopft, Berlin. Both of these firms between them recently furnished a further twenty-one locomotives of the same design and type, in certain respects slightly modified, principally by having Walschaerts motion in place of poppet valve gear. They are known as class "15 F." In addition, forty-four of these engines were built by the North British Locomotive Company, Ltd., during 1938 and 1939. Except for slight differences in detail, the boiler adopted for the 4–8–2 type engines is of a standard pattern, and is, in fact, applicable to all the new 4–8–2 locomotives, including the latest design, class "23," forming the main subject of this article. Further, in the standardisation of other parts, including the cylinder castings, as well as other of the principal details of construction, the newest locomotives follow closely those previously mentioned.

These new engines were designed in 1936, and subsequently orders were placed with Henschel und Sohn and the Berliner Maschinenbau A.G. for thirteen and seven respectively, both these contracts being later extended by a total of one hundred und sixteen engines, eighty-five to be built by Henschels and thirty-one by the Berliner Maschinenbau A.G. All are alike, though slight detail changes have been made, and the following description applies more particularly to those built by the Berliner Maschinenbau, being those with which the writer is most intimately conversant. While, as already mentioned, the new locomotives follow in general design the previous 4–8–2 classes, and more particularly the "15 F" series, they are distinguished from the former by having larger coupled wheels of 5ft. 3in. diameter to fit them for higher speeds, and to combine as far as possible the running characteristics of the six-coupled and eight-coupled types, and thus provide a locomotive which would be equally suitable for all sections of the main line. Further, to render the design generally more suitable, both from an operating standpoint and the development of a higher sustained power output, large-capacity tenders have been adopted and mechanical stokers provided. The class "23" is the largest non-articulated type of locomotive yet built for the South African Railways, the weight in working order of the engine only being no less than 111 tons, whilst the tender is the largest so far placed in service; the water capacity is 9500 gallons, and there is space for 18 tons of coal. When loaded, the weight is 107 tons, giving a total locomotive weight of 218 long tons. The use of these high-capacity tenders will in certain circumstances enable stopping for water to be avoided, and, further, provide the required fuel and water supplies necessary when working at the high rates of power output made possible by the mechanical stoker. The cylinders are of the same size as those previously employed, namely, 24in. by 28in., and in order to maintain the same maximum rated tractive effort with the larger wheels the boiler working pressure has been increased to 225 lb. per square inch, as against the 210 lb. previously used. It may here be mentioned that 24in. cylinders are the largest permissible with the existing load gauge. However, it is considered that the provision of the mechanical stoker will enable higher powers to be obtained while maintaining the standard boiler and the 24in. by 28in. cylinders.

A photograph and drawings reproduced in the accompanying engravings illustrate the new locomotives, and their principal dimensions are given in the table below.

The Boiler

Coming now to a more detailed description of these engines, the boiler first claims attention. It is of the round-top radially stayed type, and the barrel section, which is of the usual telescopic description, is made up of three courses, the front end having an outside diameter of 6ft. 3¾in., tapered to 6ft. 4½in. at the first circumferential joint. The plates are ¾in. thick, and inner and outer butt straps $\frac{9}{16}$in. and ¾in. thick are used for the longitudinal joints, which are also welded for a distance of about 14in. from each end to ensure tightness at the junction with the circumferential joints. The fire-box wrapper is in one $\frac{9}{16}$in. plate, and the back and throat plates are $\frac{9}{16}$in. and $\frac{11}{16}$in. thick. The smoke-box tube plate of 26/30-ton carbon steel is ⅞in. thick, and after being dished is turned outside round the circumference, and single-riveted into the front barrel course. The circumferential lap joints are double riveted, and for the longitudinal butt joints the inner cover straps are quadruple riveted, and the outer straps double riveted. The outside fire-box wrapper plate is double riveted to the throat and back plates. No longitudinal stays are used, but the smoke-box tube plate and the fire-box back plate are well supported by gusset type staying. The boiler shell plates and the inner and outer butt straps are of Thyssen 0·2 to 0·5 per cent. nickel steel, having a tensile strength of from 29 to 36 tons per square inch. A steam dome is not provided, but a manhole is fitted on the rear barrel course. Between the tube plates the length is 22ft. 6in. There are 136 tubes, steel, solid drawn, of outside diameter 2¼in. and thickness 11 S.W.G., and thirty-six flue tubes, 5½in. outside by $\frac{5}{16}$in. thick. The tubes are swelled to 2⅝in. at the smoke-box end, and reduced to 2⅜in. where they fit the fire-box tube plate, and the flues are increased to 5 $\frac{11}{16}$in. at the front tube plate and reduced to 4⅜in. at the fire-box end. The tubes and flues are expanded into the smoke-box tube plate. At the fire-box end they are set in thin copper sleeves, and then expanded and prossered, and finally beaded over and electrically welded. The ratio of tube bore to length is 1 to 119. The net gas area through the boiler measured at the full internal diameters of both tubes and flues is 1039 square inches, of which 488·19 square inches, or 47 per cent., is through the flue tubes. The ratio of total gas area to grate area is 11·6 per cent. The superheater comprises thirty-six sets of elements, 1½in. outside diameter and 10 S.W.G.

General Dimensions, Weights, and Proportions of the S.A.R. 4–8–2 Type Locomotive, Class "23."

Railways	South African Railways
Builders	Henschel und Sohn and Berliner Maschinenbau, Germany
Type of locomotive	4–8–2
Rail gauge	3ft. 6in.
Minimum curve radius	275ft.
Road class	"23"
Date built	1938–1939
Service	Fast passenger and freight
Rated tractive effort engines, 75 per cent.	43,200 lb.

Dimensions.

	Ft. in.
Height to top of chimney	12 11½
Height to centre of boiler	9 0
Width overall	9 11
Cylinder centres	5 11
Total length over engine and tender buffer beams	84 4½

Weights in Working Order.

	T. cwt.
On coupled wheels	72 12
On leading bogie	21 0
On trailing bissel	17 16
Total engine	111 8
Tender	107 6

Wheel Bases.

	Ft. in.
Coupled wheels	16 6
Total engine	37 0½
Tender bogie	8 8
Tender, total	30 8
Engine and tender, total	78 2½

Wheel, Diameter on Tread.

	Ft. in.
Coupled wheels	5 3
Leading bogie	2 10
Trailing bissel	2 10
Tender bogie	2 10

Engine.

Cylinders, number, diameter and stroke	Two, 24in. by 28in.
Valve gear, type	Walschaert
Valves, piston type, diameter	12in.
Maximum travel	7½in.
Steam lap	1¼in.
Exhaust lap	Nil
Lead	$\frac{13}{64}$in.

Boiler.

Steam pressure	225 lb. per sq. inch
Smallest inside diameter	6ft. 2¼in.
Largest outside diameter	6ft. 7¼in.
Fire-box length at foundation ring	7ft. 9$\frac{13}{16}$in.
Fire-box width at foundation ring	8ft.
Height, foundation ring to crown:	
Back	5ft. 11½in.
Front	7ft. 1½in.
Arch tubes, number and diameter	Five, 3in.
Boiler tubes, number and diameter	136, 2¼in.
Superheater flue tubes, number and diameter	36, 5½in.
Distance between tube plates	22ft. 6in.
Fuel	Coal
Stoker	HT-1 type, Standard Stoker Co.
Grate type	Pinhole
Grate area	62·5 sq. feet

Heating Surfaces.

	Sq. feet.
Fire-box	209·3
Arch tubes	26·2
Boiler tubes	2014
Superheater flue tubes	1165
Superheater elements	661
Combined evap. and superheat	4075·5

Tender.

Water capacity	9500 gallons
Fuel capacity	18 tons
Bogies	Six-wheel
Length over tender buffer beams	38ft. 8$\frac{7}{16}$in.
Width of tender tank	9ft. 11in.

Weight Proportions.

Weight on coupled wheels ÷ weight engine	65·0 per cent.
Weight on coupled wheels ÷ tractive effort	3·76 per cent.
Weight of engine ÷ evaporative heating surface	73·2 lb. per sq. ft.
Weight of engine ÷ combined heating surface	61·2 lb. per sq. ft.

Boiler Proportions.

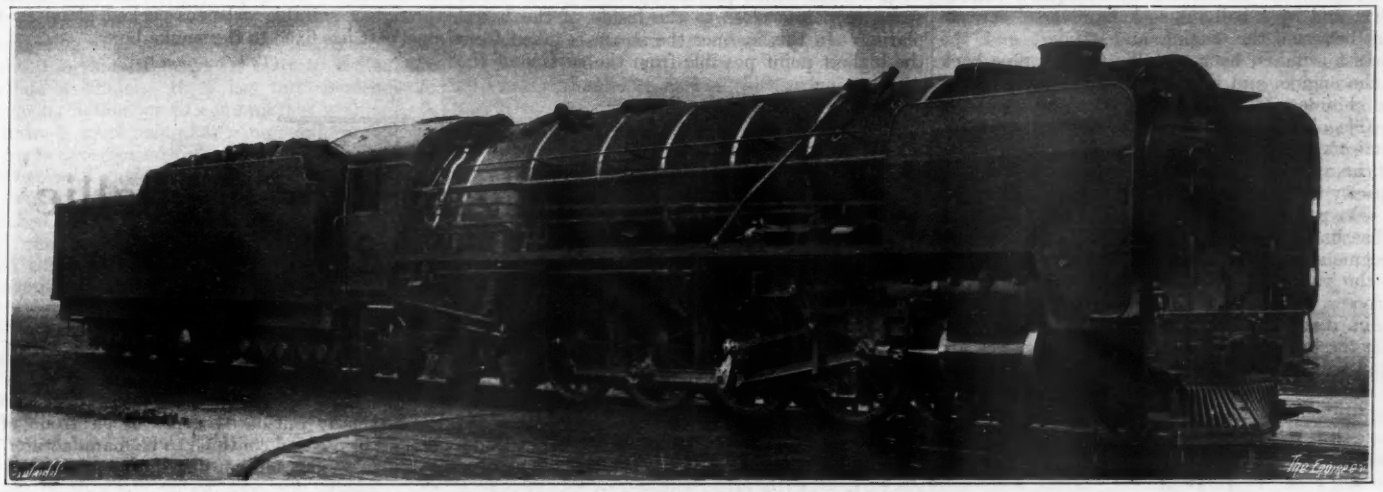
Fire-box and arch tube heating surface ÷ combined heating surface	5·78 per cent.
Flue and tube heating surface ÷ combined heating surface	78 per cent.
Superheater element heating surface ÷ combined heating surface	16·2 per cent.
Fire-box heating surface ÷ grate area	3·35 per cent.
Flue tubes heating surface ÷ grate area	50·86 per cent.
Superheat surface ÷ grate area	10·576 per cent.
Evaporative heating surface ÷ grate area	54·63 per cent.
Tractive effort grate ÷ area	691·2 lb. per sq. ft.
Tractive effort ÷ evaporative heating surface	12·65 lb. per sq. ft.
Tractive effort ÷ combined evaporative and superheat surface	10·6 lb. per sq. ft.

* Presented by permission of Mr. T. H. Watermeyer, General Manager, and Mr. W. A. J. Day, Assistant General Manager, Technical, South African Railways and Harbours.

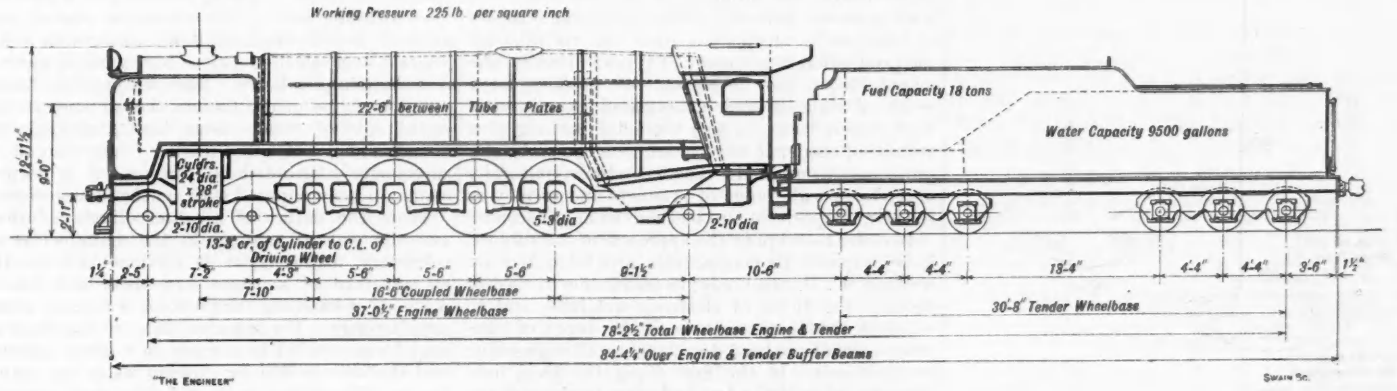
thick. They are of the short loop type, having integrally forged return bends and spherical seatings forged integrally with the pipes to make the joints with the header casting. The heating surface of the superheater is 661 square feet, or 16·4 per cent. of the combined heating surface of 4075 square feet.

The inside fire-box is of steel supplied by Lukens Steel Company, Coatsville, Pa., U.S.A. A single plate $\frac{3}{8}$in. thick comprises the wrapper, which is single-riveted to the inner back and throat plates, which are $\frac{7}{16}$in. and $\frac{5}{8}$in. thick respectively. The material complies with the A.S.T.M. specification. There are three fusible plugs in the fire-box roof, one at the front and two at the back. The fire-hole in the outer door plate is flanged inwards and in the inner door plate it is flanged outwards, thus bringing the two plates together and forming a butt joint that can be united by welding. The foundation ring is a steel forging machined all over, except on the surface next to the water space. The section is 4in. by 4in. At the foundation ring the length of the fire-box inside the throat and back plates is 8ft. $6^{11}/_{64}$in. and the width over the wrapper plate is 8ft. $9\frac{7}{8}$in. The grate has an inclination of 1 in 8·5 and an area of 62·5 square feet. It is of the round-hole table pattern, and is arranged with shaking gear, hand operated. There is also a drop section to facilitate cleaning.

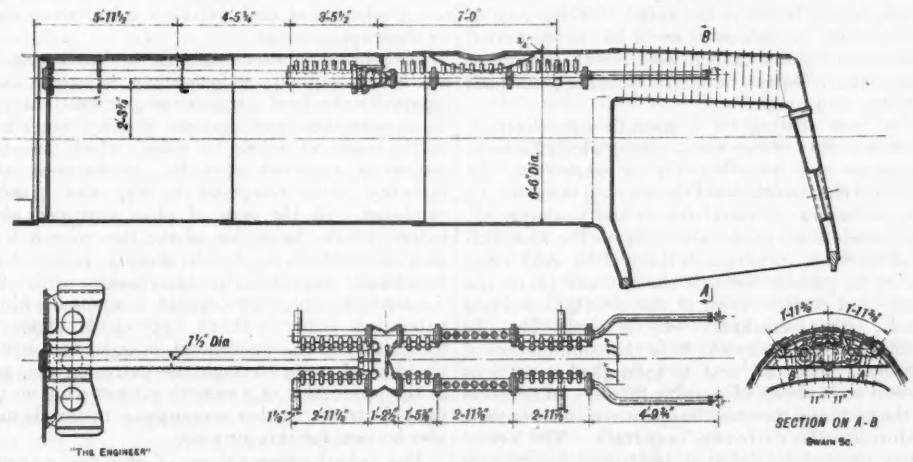
It may be here stated that for the first forty engines the rocking grates were collectively shaken by steam power, whereas the grates for the remaining ninety-six engines are separately operated in six sections by hand. The arch is carried on five arch tubes of steel, 3in. outside diameter. As in the case of the boiler tubes they are set in holes lined with copper sleeves. They are then expanded and beaded over at both ends. Suitable tapered plugs are fitted in the throat and back plates opposite each tube for fitting and cleaning purposes. The inner and outer fire-boxes are stayed together by 912 rigid and 586 flexible stays, and the crown of the inner box is supported by 254 rigid roof stays and twenty-four sling stays, which comprise the first two rows at the tube plate end. The rigid stays in the water space are $\frac{7}{8}$in. diameter, and the flexible stays have a diameter of $\frac{3}{4}$in. screwed $\frac{7}{8}$in. diameter in the inner fire-box plates. The roof stays have a diameter of $1\frac{1}{16}$in. screwed $1\frac{1}{4}$in. in the fire-box crown, and $1\frac{3}{16}$in. in the nut. All have eleven threads per inch. All the stays are of Brown Bayley's "Longstrand" or Steel Symbol St. C. 10·61, supplied by Stahlwerke Bruninghaus A.G. The same materials are used for the eighteen palm stays. The ashpan is of steel plate, electrically welded, and is of the hopper type, and is carried on the main frames. It is not attached to the foundation ring. Air inlet is provided for in the hopper portion and round the top next the foundation ring. As the ashpan is necessarily shallow where it passes over the framing and under the fire-box drenching pipes are fitted, one along each side; they are of iron and are supplied with water from the injector delivery connections. They enable all ash accumulations to be effectively washed off the shallow part of the ashpan, and into the hopper, which is fitted with a sliding bottom operated from the foot-plate. The boiler and fire-box are completely clothed with Roberts' Blue Asbestos Mattras, covered with planished steel plate, which is supported on a crinoline and bound by stainless steel bands.



SOUTH AFRICAN RAILWAYS' CLASS 21 PASSENGER LOCOMOTIVE



PRINCIPAL DIMENSIONS OF LOCOMOTIVE



ARRANGEMENT OF BOILER AND STEAM COLLECTOR

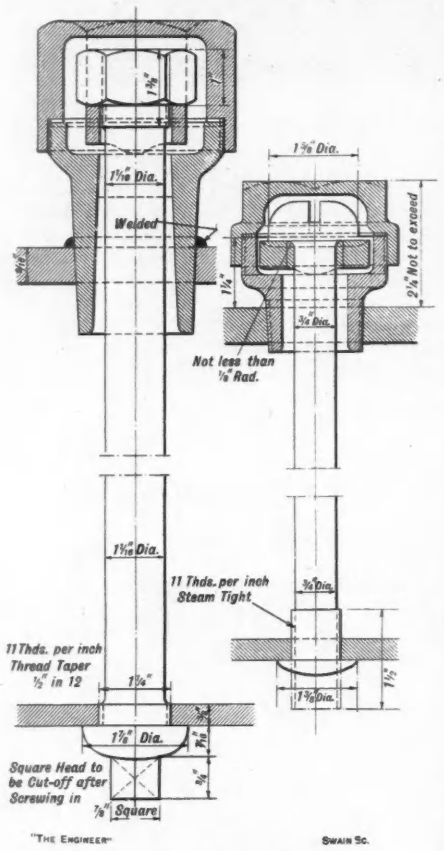
Boiler feed is supplied by two Gresham and Craven No. 13 self-acting, non-lifting injectors arranged under the footplate.† They are specified to have a capacity of about 38,000 lb. of water per hour at full boiler pressure, and delivery is made through two top-feed check valves mounted on the front end of the barrel, the water being fed through nozzles into trays carried in the top of the barrel, and designed to allow any air to escape and thus minimise corrosion.

Firing is by means of a mechanical stoker supplied by the Standard Stoker Company, Erie, Pa., U.S.A. It consists of two screw conveyors, one arranged in the bottom of the coal bunker on the tender centre line, and another articulated from it, and sloping upward at an

† Forty engines have Davies and Metcalfe exhaust steam injectors on the left-hand side and a Gresham and Craven No. 13 self-acting injector on the right-hand side.

angle to the fire door. The conveyor is driven through gearing by a two-cylinder, totally enclosed, reversible engine mounted on the tender in a space on the left-hand front corner. The coal is carried by the screw through a crusher, and from thence is elevated to the fire door, where it falls on a tray inside the fire-box, from which it is blown off by jets of steam, the intensity of which can be controlled by the fireman. In this manner it is possible to distribute the fuel as required on the grate surface. Steam to the stoker engine is taken from one of the turrets through a control valve, and by a ball-and-socket universal connection between the engine and tender, and the exhaust is taken by a metallic flexible pipe back to the engine, and is discharged into the base of the chimney in the smoke-box. The stoker is capable of delivering 15,000 lb. of coal per hour, equal to about 240 lb. per square foot of grate per hour. On test at the makers' works the capacity was 10,500 lb. per hour at an engine speed of 550 r.p.m.

The boiler fittings consist of two turrets of cast steel mounted on the fire-box. They are fitted with all the valves required for the various auxiliary purposes, and take steam through internal pipes of 3in. diameter, connecting with the main steam collector in the boiler. All the turret valves are fitted with extension spindles passing through the



FIRE-BOX ROOF AND FLEXIBLE STAYS

front of the cab with hand wheels within reach of the engine men. There are two blow-off valves, one on each front corner of the throat plate. They are of the Gestra make, and may be steam-operated from the cab. They are fitted with silencers. This type of blow-down valve is fitted to 121 engines, and the remaining fifteen, comprising part of the first twenty, have Hopkinson valves operated by connections to the cab. A Diamond soot blower is also fitted. The water gauges are of Dewrance make. Two Ross pop safety valves are fitted on the rear barrel course. The smoke-box, which is 8ft. 4½in. long and 6ft. 5¼in. diameter outside, is fitted with a spark arrestor, the arrangement being generally similar to that found in American practice. The blast pipe has a gun-metal cap, comprising the nozzle fitted with Goodfellow projecting pieces, and having a diameter of 6 15/16 in., combined with the blower ring and an additional outer ring which connects with the ejector exhaust. The chimney extends into the smoke-box to a point 5½in. from the boiler centre, and has a diameter at the choke of 1ft. 8½in. and at the top 1ft. 10 15/16 in. Behind the chimney a detachable cover gives access to the regulator valves.

STEAM SUPPLY TO THE CYLINDERS

The main steam supply to the cylinders is by means of two internal steam collectors, made up of lengths of 5in. bore steel piping running parallel inside the top of the boiler. At about half way in their length they join a cast iron junction casting having five flanges, two on each side, to take the front and rear collector pipes, and at the front facing the smoke-box an additional connection which receives the main steam pipe, passing forward along the boiler centre and between the two front lengths of the collector pipes to the superheater header. The main steam pipe, also of steel, has a bore of 7in. The collecting pipes are fitted with a number of small diameter pipes with trumpet-shaped ends, which project upwards in the steam space to points close to the inside of the barrel plating. In this manner the steam is taken from the highest point possible from the surface of the water. The regulator is of the multiple valve type supplied by the Superheater Company, and incorporated in the superheater header casting. The valves are, however, on the saturated steam side, and not on the superheater steam side, between the header and the steam chests. From the superheater to the cylinders the steam is conveyed by two seamless steel branch pipes, of 6in. bore. An expansion joint on the steam chests takes the form of a gland fitted with packing rings, the ends of the branch pipes being machined so that they may slide in the rings. The pipes pass to the steam chests through a suitable asbestos-packed gland in the steel castings fixed to the smoke-box.

(To be continued)

Some Observations on Metallic Arc Fluxes

By W. ANDREWS, B.Met.

THE progress of fabrication by metallic arc welding has now become so familiar that it is rather surprising that some degree of standardisation of the types of flux coating used has not yet begun to develop. Manufacturers of electrodes offer the welding industry a very large variety of products and the range appears to be expanding, rather than contracting, into a number of recognised types. The reasons for this lie partly with the inspection authorities, partly with the users of electrodes, and partly also with the manufacturers themselves. The inspection authorities are content to specify certain physical properties which the electrodes intended for use on work under their supervision must attain. Provided that their requirements, which, of course, are the subject of continuous research and development, are satisfied, they have not attempted as yet to formulate any rules as to the constitution of the flux. The consumer of electrodes, in addition to the foregoing requirements, has problems of his own connected with operative difficulties and the economic aspect of fabrication, which do a great deal to influence the production of a variety of types. Finally, the manufacturer has developed his product as a result of difficult and complicated experimental work which lacks, so far, the solid backing of a volume of academic work bearing on the particular problems encountered. These conditions naturally make for a wide range of products and secrecy as to their composition and methods of manufacture.

In order to simplify the approach to the subject, it is proposed to confine this article to the arc welding of mild steel only, to endeavour to classify broadly the types of electrode available and to examine the characteristics of the types of electrode which have been developed to fill engineering requirements. In the first place, the term mild steel should be defined as including the bulk of the low carbon steel used for general engineering purposes and largely covered by Lloyds specifications for steel for shipbuilding, similar Admiralty and other government department requirements, and the various British Standard Specifications for structural steel, boiler plate, &c. All this material is of a maximum of 0·25 per cent. carbon content, and in consequence is practically immune to any serious modification in its properties as a result of the thermal disturbance inevitably introduced by a fusion welding process. This has been an important factor in the rapid development of the metallic arc process since it has concentrated attention on a low carbon weld metal, capable of developing adequate strength together with high ductility and toughness.

The flux coating on a metallic arc electrode fulfils a variety of functions, among which the most important are its effect (1) in controlling the electrical characteristics of the arc; (2) in modifying the mechanism of metal fusion and consequently transmission across the arc; (3) on the metallurgical reactions occurring in the molten weld metal during its passage through the arc, and (4) on the shape and surface finish of the resultant welding bead. Other subsidiary effects could also be defined, but it is obvious that the combination of physical, electrical, and metallurgical conditions gives a wide choice of possible fluxes. In addition to the technical reasons, the operative and economic factors are also extremely important. The former often necessitate different electrodes for reasons of ease of handling and application. The latter controls such items as speed, cost, and efficiency.

This diversity is further increased by the inevitable time lag due to conservatism, and for this reason many out-dated types of electrode often remain in use and continue to be manufactured.

The classification of fluxes is complicated by the necessity for considering methods of manufacture. The majority of modern fluxes consist of a mixture of minerals, chemicals, and alloys homogeneously bonded with an alkaline silicate solution. Subsequent drying gives a hard cement of reasonable permanence, though all fluxes suffer deterioration if stored for any length of time under excessively damp conditions, especially where the atmosphere contains in addition a high proportion of carbon dioxide.

The earliest fluxes, of course, were much simpler in composition than those in general use to-day, and often consisted of simple iron oxide-silicate mixtures. The fact that iron oxide silicate compounds are found occurring naturally as a grade of blue asbestos led to the extensive use of this material, as a flux in itself, and the ease with which it could be applied as a close cord winding gave it considerable popularity. Such wrapped electrodes continue to be made, though the advance in the metallurgy of weld metal has compelled the abandonment of the earlier contentions of superiority attributed to the use of a natural compound as compared with synthetic materials.

From the nature of alkaline silicate solutions and the general analogy to the manufacture of refractory materials, it is obvious that in the manufacture of a paste flux there are several methods of handling the problem of coating a wire satisfactorily. For instance, the dry flux mixture may be suspended as a slurry in a dilute solution and the wire coated by dipping, as in the manufacture of candles, or a stiffer mixture may be applied by pressing, rolling, or extrusion through a die. In modern practice the majority of electrodes are made by extrusion of the flux as a paste through a suitable die, though the dipping process survives for certain special types of work. The extrusion process makes use both of the original patented continuous winding of cotton, asbestos, or other suitable material to ensure absolute concentricity of flux and core wire, and of plain extrusion without winding, the latter process giving a homogeneous cylinder of flux round the electrode. Representative electrodes of each type are easily recognised by their appearance.

The silicate solutions used as the binding agent are either sodium or potassium silicates, used separately or mixed in various proportions, varying in composition and specific gravity according to the ratio of alkali to silica, which has the properties of final strength, permanence and fusibility most congenial to the flux powder employed. In the case of plain extruded electrodes, where the nature of the flux may not be such as to form a smooth-flowing paste, it is sometimes desirable to incorporate with the silicate solution some organic compound, which vapourises easily without appreciable effect on the quality of the weld metal, in order to assist in the flow of paste through the extrusion die, and in the production of a smooth even coating on the final electrode. Other non-organic materials may also be used for this purpose.

The actual compositions of the flux powders remain, in the vast majority of cases, manu-

facturers' secrets and little information has been published on the subject. The general principles of electrode flux compositions, however, are fairly well known, and in most commercial mild steel electrodes they usually consist of mixtures of mineral silicates, ferro-alloys, metallic oxides, fluorides, and carbonates, together with organic compounds, apart from those used to assist extrusion. Economic conditions demand that the materials should be plentiful and reasonably cheap so that natural minerals, rather than prepared chemicals, are more frequently used.

Apart from the chemical and physical properties determining the value of a flux ingredient, one essential is that it should be inert to the silicate used as a binder. If it has any tendency to cementing action, or to combination with silicate to form a more complex compound, premature setting is experienced and the paste loses plasticity and becomes unworkable. Similarly, compounds of a strong acid and a weak base are liable to be attacked by the excess alkalinity of the silicate with the precipitation of gelatinous silica and again complete loss of plasticity. This practical requirement limits the adoption, without special treatment, of many materials which would otherwise be useful as flux ingredients. An example of the tendency to double silicate formation is calcium hydroxide which will, in a short time, cause a silicate bound paste to set to a hard cement. Similarly, some chlorides, *e.g.* aluminium chloride, are acid in reaction and cause instantaneous separation of gelatinous silica from the silicate. Even milder acid radicles, *e.g.* boric acid in combination with weak bases, may have this effect though special protective treatments can in some cases be developed. Except in certain cases, however, the flux material need not be completely water insoluble, so long as the product of solution has a neutral reaction.

The most frequently used of the various materials are as follows :—Of the silicates kaolin, the soda and potash felspars, less frequently the lime bearing varieties which have higher melting points, the pyroxenes such as enstatite [(MgFe)O.SiO_2] and diopside (CaO MgO $2SiO_2$), the amphiboles, particularly the various grades of asbestos represented in this class, potash, and more rarely magnesian mica (the sodium mica, paragonite, is not commercially available), minerals of the talc-serpentine group which also includes the Canadian asbestos, chrysotile, and occasionally less plentiful materials such as some grades of garnet. Of the metallic oxides, the various different grades of iron oxide are widely used, including hematite of varying silica content, magnetite and those grades known as micaceous iron oxide owing to their mode of occurrence. Other frequently used metallic oxides are the various oxides of manganese, titanium oxide, either as rutile, which is usually of at least 95 per cent. purity or as the various grades of ilmenite which are available, and occasionally zirconium oxide. As explained previously, calcium oxide, or rather the hydroxide, cannot readily be used in conjunction with silicate solutions but, owing to its much greater insolubility, caustic magnesia obtained by calcining magnesite reacts very much more slowly and is consequently a practicable material.

Most of the better known ferro-alloys are regular constituents of flux coatings as a means of introducing alloying elements. The most familiar and important of these are the ferro-manganese alloys, both low carbon electric furnace quality, or the low grade form containing up to 6 per cent. of combined carbon. The main use of manganese as distinct from an alloying material, is as a deoxidant, just as in steel making, and most high grade electrodes contain a sufficient proportion to compensate for that oxidised out of the weld metal during exposure to the high temperature of the arc. Ferro-silicon is also used for a similar purpose, but here trouble is often encountered owing to its susceptibility to chemical attack by the alkaline silicate solutions, unless special precautions are taken. Ferro-titanium and ferro-vanadium, though expensive, may also be used for deoxidation in combination with some of these alloys. Other ferro-alloys, or pure metals, are used where an alloy steel deposit is being made up synthetically, or where the loss during welding has to be compensated for.

The carbonates used include all the forms of calcium carbonate commercially available, such as limestone of high purity, calcite, crushed marble powder, and precipitated forms of carbonate. Dolomite and magnesite are extensively used and the latter may also be used in the calcined form since its insolubility and low reactivity as compared with calcium oxide render it practicable. Calcined or dead burnt dolomite has to be specially treated owing to its high calcium oxide content and consequent reactivity with silicate solutions. Manganese carbonate, as rhodochrosite is frequently employed as a flux constituent and there is a wide usage of the various mineral oxides of manganese, notably braunite (Mn_2O_3) hausmannite (Mn_3O_4) and pyrolusite (MnO_2). The former two are often calcined to eliminate organic matter and ensure reasonable constancy of composition. Chalybite natural iron carbonate is rarely used since it is practically always found associated with phosphate impurities. Similarly, the natural barium carbonate, witherite, is often associated with lead and sulphur, and on this account may be unsafe to use. Lead impurities are undesirable because of their generally low boiling points and the danger of poison associated with them, and sulphur, of course, because of its known deleterious action on steel. Another carbonate which has been proposed and used to some extent is strontium carbonate, found as the mineral strontianite, but as the latter is not particularly abundant the chemically produced material must be used and price considerations interfere. In addition the alkaline carbonate of sodium and potassium are extensively employed.

Besides the oxides of manganese and iron, other metallic oxides are also employed. By far the most important of these is the di-oxide of titanium, found as the mineral rutile (the other crystalline varieties, brookite and anatase, are comparatively rare). Zirconia, a similar higher melting point material has been proposed and used to a small extent and aluminium oxide has also a certain value, but neither of these materials approaches rutile in properties or popularity as a flux constituent. The compounds of titanium in nature are scarce, compared with the silicates, and only the various grades of ilmenite, compounds of iron and titanium oxides, form an alternative supply of any abundance. Sphene or titanite, calcium silico-titanate (CaO SiO_2 TiO_2) is a possible alternative but is little used on account of irregularity of supply and composition. It is also liable to be contaminated with phosphates. Perovskite, the pure calcium titanate, would probably be useful but does not appear to occur in commercial quantities.

In addition to the mineral constituents and binding agents used in fluxes there are, in many cases, organic materials incorporated for various reasons. Briefly, these can be divided into two types ; first, those added for their effect on the mechanical behaviour of the flux either in improving smoothness in extrusion, final flexibility of the coating after drying, or for other reasons connected with the manufacturing process. Secondly, the large class of cellulosic and similar compounds used in so-called gas shielded electrodes. The theory behind the use of these latter materials, which are all based on the presence in the electrode flux of a material based on the (C_6 H_{10} O_5)x type of molecule, is that under the conditions obtaining in the metallic arc, primary decomposition occurs into a mixture of carbon monoxide and hydrogen which surrounds the molten metal and slag with an intensely reducing atmosphere, serving to exclude contamination by oxygen and nitrogen. Owing to the large proportion of hydrogen present in this arc atmosphere it is also claimed that the electrical resistance to the passage of an arc is increased, resulting in a higher arc voltage, more overall consumption of energy in the arc and consequently quicker welding. There has been, and continues to be, some controversy as to the justification of some of these claims for the effect of these compounds. It has been repeatedly proved that plain slag fluxes, without any additions of this type of organic matter, can produce weld metal equally low in nitrogen content. Observation also suggests that there is little to choose between high quality electrodes, with or without gas shielding additions, from the point of view of iron oxide and other non-metallic inclusions. Further, the highest physical properties in the weld metal are obtainable from each type. What is definite, however, is that the nature of the welding arc obtained from so-called gas shielding additions is often very different from that observed in plain slag electrodes. It is possible, in cases where the proportion of such material is high, to obtain a very harsh direct arc suitable for making welds on unprepared edges in steel of substantial thickness or, in short, to use a trade term, having high "penetration"—an obviously valuable feature for some classes of work.

Finally, having given a general outline of the range of materials used in arc welding fluxes for steel, the question of classification arises. It would appear at first sight that it would be a simple matter to classify bases as acid, basic, and neutral, according to a preponderance of acid oxides, such as silica, basic oxides, such as lime, or neutral materials. This method, however, has its objections, one of them being that reactions in the arc take place at much higher temperatures than in steel making practice and it is by no means certain that the reactions occurring are truly parallel. It appears preferable, therefore, to adopt some system of classification dependent on the nature of the constituents used in the flux coating and the character of the resultant slag. The following system is tentative only and does not presume to include every type of electrode which has been proposed or used for mild steel, nor does it claim to deal with other than British practice. It does, however, cover the majority of electrodes in general use in this country and it is felt that it may be of some assistance to users in assisting in recognising the various types encountered. In the first place two main divisions of electrode coatings must be recognised.

1. Arc Stabilisers only.	Applied as an ultra thin wash only.
2. True Fluxes.	In which the coating may be light or heavy, but fulfils the true function of a flux in modifying the action of the atmosphere on the molten metal to a greater or lesser extent.

Arc stabiliser coatings represent coatings applied purely for electrical reasons, and have long been substantially displaced from all but the most unimportant work. Owing, however, to the difficulties encountered in the combination of an adequate flux with a continuous automatic welding process a fair amount of welding is still carried out using materials of this character to improve the behaviour of the arc.

True fluxes in addition to exercising their effect on the electrical characteristics of the arc are employed for their metallurgical and mechanical effect on the deposit. According to whether they contain cellulosic matter and are of the so-called gas shielded type, or rely on the fluxing properties of the chemicals or minerals they contain, they may be divided into :

1. Slag Shielded types.
2. Gas Shielded types.

Further, fluxes may be sub-divided by method of manufacture, *i.e.* dipped, wrapped, wound, extruded or plain extruded. It is probably best, therefore, to keep method of manufacture and composition of coating separate. The following is the final proposed method.

Classification by Method of Manufacture.

Main head	Sub-head	Remarks
1. Dipped Process.	(*a*) Wash coating	Single very light dip nearly always too small in quantity to act as a true flux. Usually an arc stabiliser only, *e.g.* $CaCO_3$ and other carbonates.
	(*b*) Heavy coating	Several dips to give a coating thickness of the same average as extruded electrodes.
2. Wrapped Process.	(*a*) Single coating.	Materials such as blue asbestos which lend themselves readily to application to the electrode as a yarn winding.
	(*b*) Double coating.	Two different coatings may be employed, the outer one being similar to (*a*), and the inner a paste or other type.
3. Wound Extruded.	—	Cotton, various types of asbestos, paper or other cellulosic material, all of which may be reinforced with wire, or wire itself may be employed. The winding agent forms an open spiral round the rod and the flux is extruded into the spaces by passage through a die under pressure.
4. Plain Extruded.	—	A paste is extruded directly on to the rod, forming an uninterrupted sleeve of flux. Very stiff pastes and high pressures are usually employed and a smooth intense arc obtained. Rods of this type are difficult to bend without breaking off the coating.

TYPES OF FLUX COATING EMPLOYED

The constituent sub-heading gives type constituents only, *e.g.* where titanium oxide-silica

alloy is quoted it is intended to convey that a metal oxide of the titanium type is used in conjunction with some silicate bearing mineral or minerals in combination and the possible variations in composition are almost infinite.

Type	Constituent	Description
1. Arc Stabilisers.	Carbonates TiO_2 and similar materials.	See manufacture.
2. Slag Shielded.	Iron Oxide-Silica.	Mixtures of various iron oxides and silica or silicates are used in various proportions. Blue asbestos wrapped electrodes also come into this classification, though in this case a compound instead of separate constituents is used. The coating is oxidising and in consequence the weld metal contains little or no manganese and low carbon. It thus approximates in composition to pure iron, though porosity and slag inclusions may be frequent. Electrodes of this class are usually sold because of the running properties and finish obtainable on the weld metal.
	Iron Oxide-Silica Alloy.	Basically similar to group (*a*) but of wider scope, less oxidising in nature and often modified by carbonates and other oxides. Electrodes of this class contain de-oxidising ferro-alloys, usually ferro-manganese, and as a result the weld metal composition approaches that of ordinary mild steel. The slag of this type of weld metal is usually inflated and very easily removed.
	Titanium Oxide-Alloy.	Titanium oxide, usually in the form of rutile, forms a large proportion of the flux, together with ferro-manganese and other alloys and fluxing constituents, such as silicates. The high rutile content results in flat surface deposit of excellent appearance and a solid but easily removed slag.
	Titanium Oxide-Silica Alloy.	Differs from the previous class of rod in that on the average much less titanium oxide and more silicates are used. The result is a slag of greater adaptability for "three position" welding.
	Fluorides and other chemicals.	Fluorides are typical of neutral materials which may be used to make an effective flux. Natural calcium fluoride or fluor-spar is a common example. They are little used in the case of mild steel though useful in non-ferrous metals and special alloy steels.
3. Gas Shielded.		As has been explained, this term applies to electrodes in which in addition to a mineral slag an organic material of the cellulose class is incorporated. This organic material is claimed to decompose into carbon monoxide and hydrogen surrounding the arc with a reducing atmosphere and thus excluding oxide and nitride contamination. In consequence the oxidising non-alloy types are not represented in this class, nor do fluoride fluxes find any appreciable favour in conjunction with such material. Gas shielded electrodes, therefore, usually fall into the three middle classes of the slag shielded type. (*a*) Iron Oxide-Silica-Alloy. (*b*) Titanium Oxide-Alloy. (*c*) Titanium Oxide-Silica-Alloy.

The above classification is naturally somewhat general in its scope and cannot, of course, be claimed to include all the commercial electrodes on the market. It will be found, however, that most of the better known types can be placed in one or the other of these classifications and a little experience with the operation of an electrode and the observation of the type of slag produced from known types soon enables the experienced engineer to recognise the class of flux used. It is, for instance, comparatively easy to distinguish an all-silicate flux from one containing high proportions of titanium oxide, or to recognise the presence of high proportions of fluorides. It is to be hoped that as development of the use of welding occurs this question of classification of types of fluxes will be considered by the appropriate authorities and some standard proposed which will reduce the very wide variety at present available.

Submerged Barriers for Shore Protection

By E. E. R. TRATMAN

WITH its frontage of approximately 35 miles along the west side of Lake Michigan, the city of Chicago, U.S.A., has a serious problem in protecting its shore line from devastation and erosion by the waves and currents of heavy storms, more especially those from the north-east, which have a sweep of 100 miles or so across the open lake. Nearly 30 miles of this lake frontage consists of public parks, extending north and south of the mouth of the Chicago River. This river mouth is closed and controlled by a navigation lock, and the regulated flow is from the lake and through or "up" the river. A large water area adjacent to the mouth of the river is a ship and yacht harbour, protected by a concrete breakwater. In this area is a masonry pier nearly a mile long, having ships' berths, two-storey transit sheds, and large recreation spaces for public use. Private property, steel works, industrial plants, and railway lines occupy some relatively short portions of the lake frontage. There are occasional sand beaches for bathing and recreation, but they are liable to severe erosion by storms, although the ravages are in some cases remedied by pumping in great quantities of sand from large hydraulic or suction hopper dredges. Jetties have been used in some places for protection, but generally without much effect.

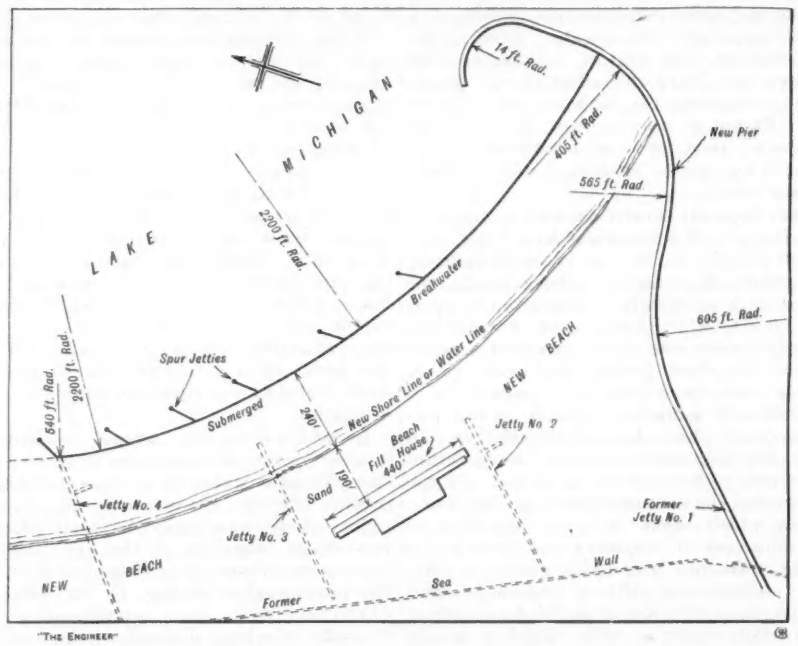


FIG. 1—SHORE PROTECTION WORKS ON THE LINCOLN PARK FRONTAGE

A large proportion of this lake-front park area consists of made land, filled in gradually from time to time. Usually a bulkhead or sea wall was built in the water along an adopted shore line and filling by tipping was carried on until it reached the bulkhead, which then became the line of shore protection. One of the earliest forms of construction for the construction of bulkheads, and also for water front protection of existing land, consisted of two parallel rows of timber piles, connected by longitudinal waling timbers and transverse wooden struts and iron tie-rods, with rough rock filling for the space between the rows and a capping of massive quarry blocks laid at random to give an irregular surface approximately 5ft. above the water level. In time, however, some of the piles would be loosened or broken by wave action and ice pressure, and the bottom eroded by waves or undertow, so that the rock filling would settle, perhaps breaking or displacing more piles, so that breaches would be formed. Repair of such construction was not an easy matter, and in many cases it was neglected.

Another plan was to build a flatly sloping paved beach, consisting of concrete poured in place in large slabs, or of deep stone block paving on a concrete base. The slope was about 1 in 12, and the toe—a little above normal water-level—was protected by a line of timber piles and sheet piling. In some places, mainly for reconstruction after storms, interlocking concrete sheet piles were driven along the toe of the paved beach. But here again the waves would break or displace the piles, forming gaps through which the water would drive in with force and blow up the paving in great blocks. A small portion of the frontage has a concrete sea wall of limited height, generally with loose rock filling in front, along the lake bottom. None of these protective works provided facilities for bathing, but with the growth of the city and the development of its lake-front parks, it became very desirable to increase the extent of sand beaches.

Some twelve years ago an experiment was tried by building off-shore protective works out in deep water, instead of along the shore line, the structure consisting of a submerged barrier or breakwater. The theory was—and it seems to have been proved by experience—that the sweep of the waves would be broken up by the obstruction, so that their destructive force would be dissipated or expended in the semi-enclosed stretch of water between the barrier and the shore. Furthermore, the retreating water would oppose the incoming waves. In addition, the undertow flowing back along the bottom would strike the inner side of the submerged barrier and thus be compelled to rise vertically, this upward flow assisting to break up the sweep of water shoreward over the barrier.

In this experimental case, the construction consisted of a double row of timber piles with rock filling, similar to the shore line wall or bulkhead already described, but differing from it in that the top or crest was about 3ft. below the normal water-level. Sand was pumped in to form a beach sloping from the shore line to the toe of the submerged barrier. This particular beach has been maintained satisfactorily, the winds and waves giving it a slope of about 1 in 32.

A series of severe winter storms a few years ago practically wrecked a part of the Lincoln Park frontage, in the north part of the city, where a long stretch of paved sloping beach had been built. It was necessary to take some prompt action to protect the damaged section from further attacks. The plan adopted was to build several jetties about 500ft. long and 600ft. apart, pointing approximately north-east, or at an angle of about 70 degrees with the shore line. Some of these jetties are shown by dotted lines in Fig. 1. They are of the pile and rock type already mentioned as used for shore walls or bulkheads. Besides acting to break up the sweep and destructive power of the waves, it was expected that swirling currents or eddies in the spaces between the jetties would cause a deposition of sand to form a protective foreshore. To facilitate such action, each jetty had on its lee side, and near its outer end, a

short spur to check the eddies. However, while the jetties did serve as protective works, there was practically no deposition of sand, as there is but slight littoral current at this place. On the other hand, the jetties were unsightly features of the park and the lake front, especially as after successive storms they became more or less damaged.

In planning for some permanent protection it was decided to try the submerged barrier system, already in use further down the shore. It was thought preferable to establish such works out in some 15ft. of water, rather than to rely upon any

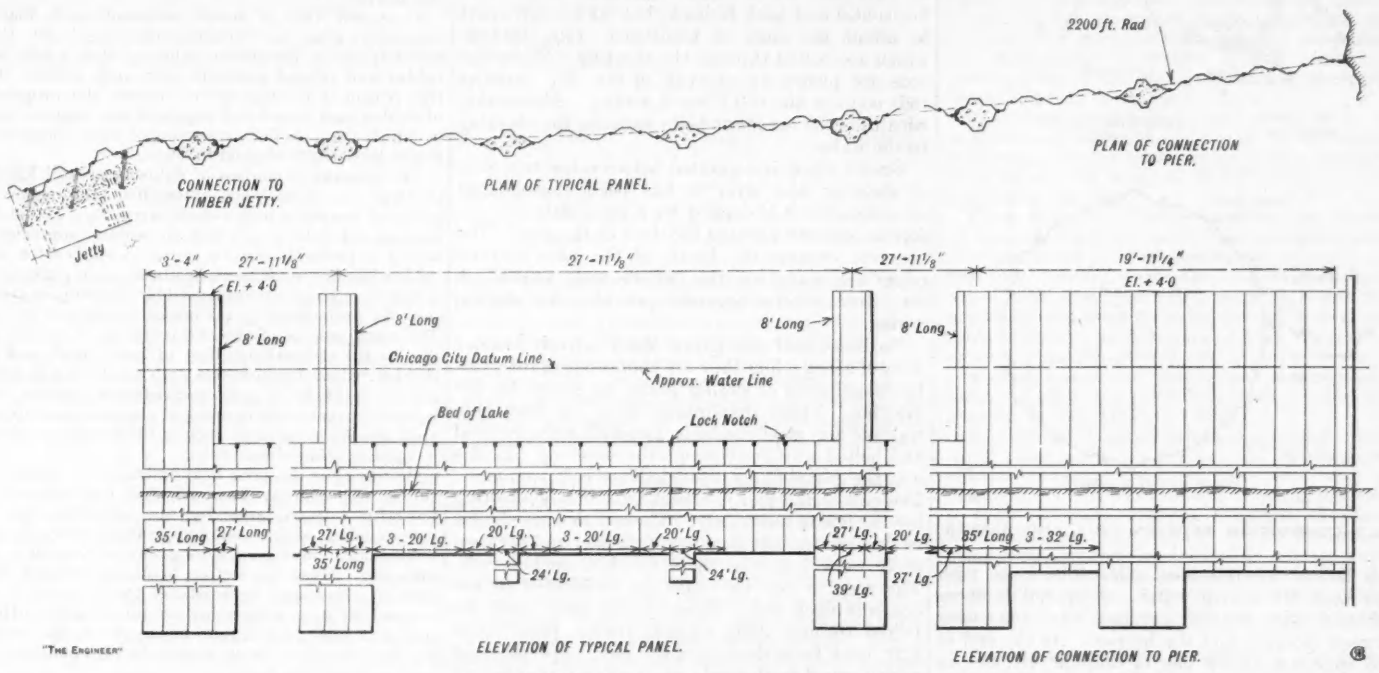


FIG. 2—ARRANGEMENT OF STEEL PROTECTIVE WORK

form of sea wall along the shore line. Furthermore, this plan would provide for filling a sand beach behind the protective line, and thus extend the bathing and recreation facilities on a large scale. A length of nearly 2000ft. of beach was thus built in 1938, and 4000ft. more in 1939. The lake bed normally consists of 2–5ft. of sand, underlaid by varying strata of clay and gravel on rock at depths of 60–80ft.

With the same principle as in the earlier submerged work, the type of construction for the new submerged structure is entirely different. It consists essentially of a single line of steel sheet piling, reinforced at intervals by hollow piles—built of the interlocking steel sheet piles—filled with concrete. This barrier or breakwater is some 500ft. from shore and connects the outer ends of the jetties, so as to form semi-enclosed spaces approximately 500ft. by 600ft. At intervals

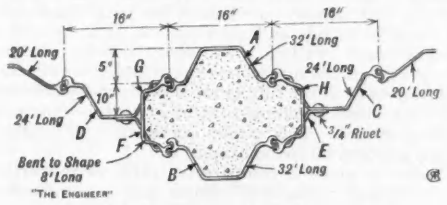


FIG. 3—BUILT-UP BUTTRESS PILE

of about 28ft. there are piles extending high enough above the water to mark the line of the barrier and also to assist in breaking up the waves. Sand was pumped in from large suction hopper dredgers to form a beach, leaving the winds, waves, and currents to adjust the slope within the several spaces between the jetties.

At the south end, or the beginning of the barrier, the first of the old jetties was replaced by a solid pier, curved in plan and extending nearly 2000ft. from shore. Its outer end was formed with a hook to check and retain any drifting sand. From the side of this pier the submerged barrier extends on a long curve of 2200ft. radius until it meets the end of the next jetty, and then continues parallel with the shore line. In the plan, Fig. 1, are shown the original shore line—which was defined by a sea-wall or bulkhead; the old jetties; the new pier; and the submerged breakwater. It shows also the tentative shore line of the new sand beach. But as a matter of fact, in the spaces or "compartments" formed by the jetties and breakwater in the stretch north—or to the left —of that shown on the plan, the tendency is to form a separate concave shore line in each compartment, instead of a continuous line through all the compartments.

Details of the design of this steel protective work are shown in Fig. 2. In the first section, built in 1938, the crest of the line of sheet piling is 4ft. below normal water-level, which is the datum line for the city of Chicago. For the next extension, which will be to the left, or north, of jetty No. 4 in Fig. 1, it is intended to make this distance 3ft. In both cases, the tall marker piles, 28ft. apart, extend 4ft. above the datum line. It is of interest to note that records covering a long term of years show that the actual level of the lake has a range of 8ft., from 4ft. above to 4ft. below the theoretical datum line, so that references to the water-line are indefinite. This datum line is 579·48ft. above mean sea level in the harbour at New York.

Taking the nearly 2000ft. of the present work as built in 1938, and as shown in Fig. 2, it will be seen that the submerged barrier is composed of panels approximately 28ft. long, defined by the tall or so-called buttress piles extending 4ft. above datum level. Each of these hollow piles is composed of sheet piles interlocked and having half-piles riveted on to form the lock for adjacent piles, while an 8ft. length is added to extend above water, as described. The panel between the tall piles contains fifteen piles 20ft. long, except that at two points there are hollow concrete-filled piles 24ft. long, very similar to the buttress piles, but not extending above the water. It will be noted that no waling is used on the steel sheeting. To ensure an even horizontal line for the top of the submerged barrier, each pile has the outer rib of one interlocking groove burned off for a depth of 2in. from the top, and the corresponding part of the other groove is bent inward for the same depth. In this way, each pile is driven until the bent "thumb" strikes the top of the groove of the adjacent pile, and so cannot be driven lower than the latter.

The built-up hollow steel "buttress" piles which extend above the water are of interest in their construction, which is shown in Fig. 3. Two side piles, A and B, are interlocked with two end piles, C and D, while closure is completed by two half-piles, E and F, which are interlocked with A and B and riveted to C and D. But C, D, E, and F are 24ft. long, while A and B are 32ft. long and extend 8ft. above the others. The closure to full height is completed by two 8ft. piles, G and H, which are bent to the shape shown and are interlocked with the tall piles A and B. The other hollow piles, which do not extend above water, are of similar design, except that the six piles, A to F, are all 24ft. long, and the additional short piles are omitted.

At the right of the drawing, Fig. 2, is shown the connection of the barrier with the pier. Here there is a 19ft. panel of 32ft. interlocking piles and two 35ft. concrete-filled piles, all extending 4ft. above water. The first interlocking pile is locked with the stem of a T-shaped pile forming part of the steel side of the pier. And at the left of the same drawing is shown the connection of the barrier with the timber jetty No. 4 (in Fig. 1). Here the steel sheeting is through-bolted to the wood piles in the end of the jetty.

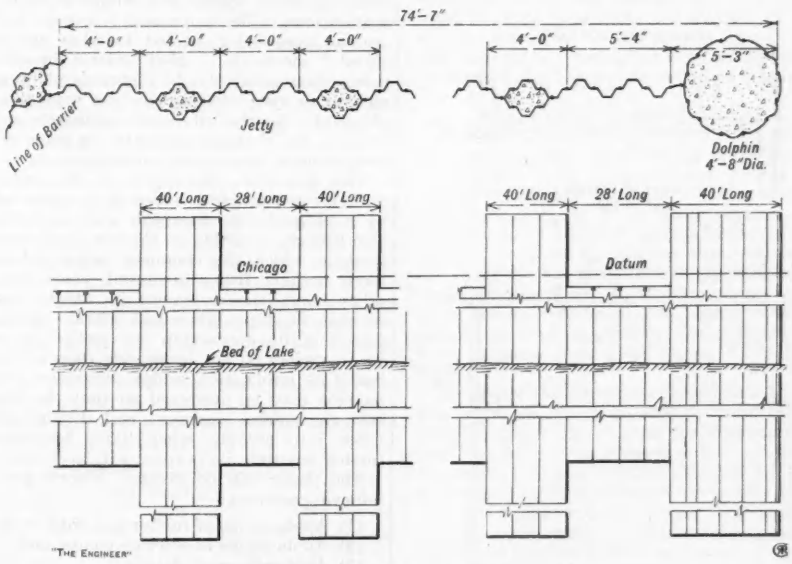


FIG. 4—ARRANGEMENT OF SHORT SPURS

Referring again to Fig. 1, it will be seen that along the outer face of the submerged barrier there

is a series of short spurs or jetties about 75ft. long and at an angle of 45 deg. with the face of the barrier. They were designed to prevent erosion along the toe of the sheeting and also to aid in breaking up the force of the waves. Each spur, as shown in Fig. 4, consists of a single line of the steel sheeting, arranged in sets of three 28ft. piles, having their tops 4ft. below water, alternating

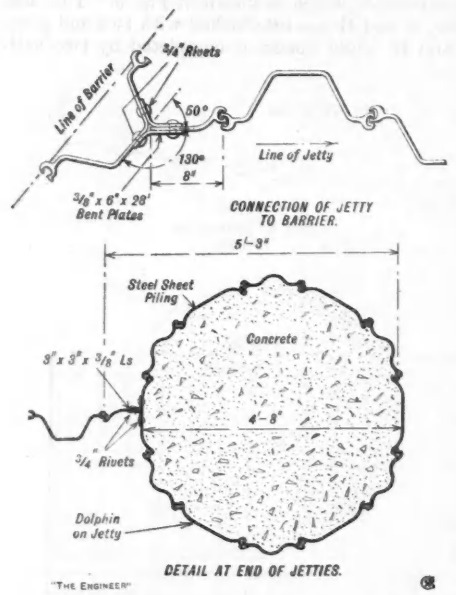


FIG. 5—CONNECTION BETWEEN SPUR AND BARRIER

with hollow concrete-filled piles 40ft. long, with their tops 4ft. above water. A special built-up T-shaped pile, Fig. 5, provides the connection between the spur and the barrier. At the end of each spur is a hollow pier or dolphin, 4ft. 8in. in diameter, also shown in Fig. 5, composed of 12in. steel piles 40ft. long and rising 4ft. above water. Alternate piles are bent in the web so as to form

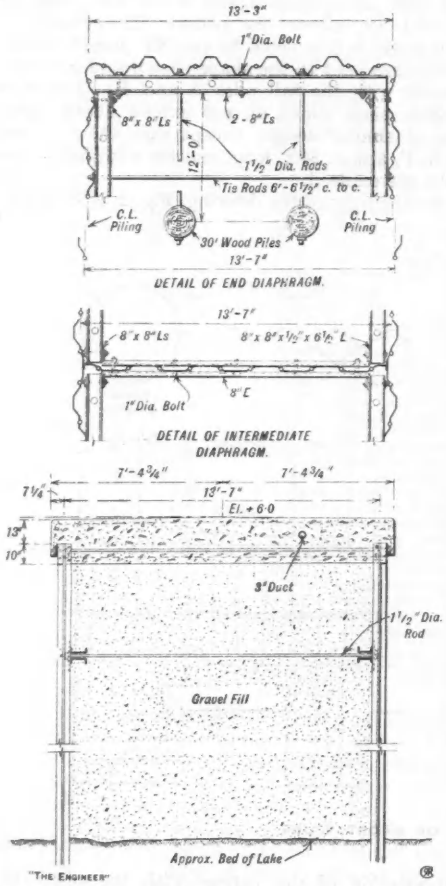


FIG. 6—TYPICAL SECTION OF NEW PIER

a series of vertical corrugations in the face of the dolphin. In the new extension northward, however, these spur jetties are to be omitted, erosion along the toe of the barrier being prevented at much less expense by depositing rip-rap or large loose rock along the toe.

In placing the sand for the new beach inside the barrier, it was at first filled to 5ft. below datum along the toe of the steel sheeting. But in view of the adjustment of the beach by wave action, this depth was changed to 8ft. below datum. The adjusted slope of the beach is approximately 1 in 32.

The long and curved pier from which the submerged barrier starts is composed of two lines of 40ft. steel sheet piles of troughed section, 14ft. apart, as shown by the typical section in Fig. 6. At the top of each row is an outside longitudinal wale consisting of a 4in. by 6in. angle, with the shorter leg outstanding. About 5ft. below, or at water-level, each row has an inside wale consisting of two 8in. rolled steel channels, with webs horizontal and back to back, but far enough apart to admit the ends of transverse 1½in. tie-rods which are bolted through the sheeting. These tie-rods are placed at intervals of 6ft. 6in. Similar rods connect the top lines of waling. Alternating with the rods are short bolts securing the sheeting to the wales.

Gravel filling is deposited between the two rows of sheeting, and after it has been consolidated or compacted it is capped by a 24in. slab of reinforced concrete forming the deck of the pier. The concrete encases the heads of the piles and its edges are seated on the outside wale angles. A 3in. duct in the concrete provides for electric wiring.

To brace and strengthen the relatively slender lines of sheet piling they are connected at intervals by diaphragms of similar piling, as shown by the drawing. These diaphragms have on each side wales of 8in. steel channels, but with webs vertical and bolted together through the sheeting. In this way the gravel filling is divided into compartments. The end of the pier is closed by a line of sheeting having inside wales only. These wales are similar to those on the side sheeting of the pier and between their webs pass the ends of 1½in. anchor rods. The rods in the top wale are embedded in the concrete deck slab; those of the lower wale are bolted through 30ft. wooden anchor piles about 12ft. back from the end of the pier. Special sheet piles, curved in the web, are used to form the end corners of the pier.

The Chemist and the Ship*

By J. E. HOLMSTROM, B.Sc., Ph.D., Assoc. M. Inst. C.E.

INTRODUCTION

IN so far as problems in shipbuilding and marine engineering are problems of materials they are also problems in applied chemistry. The business of the chemical industry—not alone, but working in close collaboration with the other industries that surround it on all sides—is the development, production, and continual improvement of materials whatever their origins and whatever their ultimate applications. The scope and interests of chemistry are far from being limited to what are commonly called "chemicals"; they extend directly, or still more often indirectly, to materials of every kind—natural or synthetic, mineral or vegetable, rare or plentiful. Nearly all other industries depend, in fact, on the chemical industry for some of the preconditions or their work and progress.

This being so, the object of the present paper is to bring together a series of pictures each drawn by a chemist able to speak with authority on his own branch, outlining on the one hand certain directions in which the chemical industry has brought forth notable fruits in recent years and, on the other hand, the directions in which these are of interest to shipbuilders and marine engineers. By reason of its authorship the picture is necessarily less complete on the latter side than on the former, but if its publication evokes discussion whereby the balance may be corrected so that the chemist can take the marine engineer's and shipbuilder's special needs into account when fixing his objective for further research, its purpose will have been served.

The paper will be divided, accordingly, into the following sections:—

(1) Applications of rubber and rubber products.
(2) Applications of chlorine compounds.
(3) Applications of plastics.
(4) Paints and finishes.
(5) Defence against fire.
(6) Pest control.
(7) Metallurgical processes.
(8) Refrigeration and storage of perishables.

Two other branches of the chemical industry of interest to members of the Institute, namely, boiler feed water treatments and non-ferrous metals, have been deemed sufficiently important to be made the subject of separate papers already published.

In concluding this introductory note the titular author wishes to make clear that his own part in producing the paper has been almost entirely editorial, and that whatever value it may possess is due to the work of his specialist colleagues in their respective fields.

* The Institute of Marine Engineers.

APPLICATIONS OF RUBBER AND RELATED PRODUCTS†

The rapid strides made by the rubber industry during the last few decades undoubtedly are intimately bound up with the rise of the automobile industry. At first rubber was used almost exclusively in tyres, but recently the automobile engineer has become "rubber-conscious" and in some cases as much rubber is used in the actual chassis and body construction of the motor car as in the tyres themselves.

It is felt that if naval architects and marine engineers were as "rubber-conscious" as their counterparts in the motor industry, they might find rubber and related products even more useful. For this reason it is proposed to discuss the properties of rubber and its related products and suggest ways in which the peculiar properties of such compounds might be usefully applied in ships.

The general properties of rubber are well known, in that it is a resilient, extensible, and retractible material having a high tensile strength. The shortcomings of rubber are not so widely appreciated, and it is probably due to errors in application that rubber has not made more headway as an engineering material. A new material suitable for many purposes may be prejudiced by an initial mistake in its use. The most serious of the shortcomings of rubber are due to the deleterious effect of heat, light, and oil. Rubber, when it encounters such conditions in severe degree, is likely to give unsatisfactory service, and it is unfortunate that in many, if not most, engineering applications one or more of these influences are present to some considerable extent.

At one time the poor heat resistance of vulcanised rubber was a great drawback, but the discovery of powerful anti-oxidants by the chemist and the development of low sulphur compounding by the technologist have gone a long way to overcome this difficulty. Even so, certain synthetic rubbers show definite advantages in resistance to heat, and in this connection it is interesting to note that synthetic products such as neoprene never revert like rubber, i.e. do not soften to an almost liquid condition but tend gradually to harden.

When we come to consider the effects of light, oxidation and oil, it has to be admitted that rubber, even when compounded according to the most modern developments, leaves much to be desired. It is under such conditions that the modern synthetic rubbers and their related products come into their own, and it will be convenient at this point to review the materials which are now available.

Synthetic Rubbers.—Synthetic rubbers may conveniently be divided into two classes:—

(*a*) Those closely related to natural rubber in chemical structure, *e.g.* poly-chlorobutadiene or neoprene, and poly-butadiene or Buna.
(*b*) Those having no chemical relationship with natural rubber, consisting mainly of a class of products known as "thioplasts," of which Vulcaplas, Thiokol, and Perduren are important examples.

The members of class (*a*) have mechanical properties equal or superior to those of natural rubber together with far greater resistance to light, heat, and oil, while those of class (*b*) are usually less resilient, and of lower tensile strength than natural rubber, but usually swell even less than materials of class (*a*) in oils and solvents. It is to be noted that a slight swelling in oil may in some circumstances be an advantage, since provided the mechanical properties of the rubber are not adversely affected by such slight swelling a tighter joint is obtained during service. This applies particularly to jointing rings, gaskets, oil-sealing tapes, &c.

Below is given a comparative table of properties of a typical vulcanised rubber and a comparable vulcanised synthetic rubber (neoprene).

TABLE I.

	Rubber	Neoprene
Hardness (Shore)	60	60
Tensile strength (Kgs./cm.²) ...	216	224
Elongation per cent. at break ...	625	602
Resilience per cent.	63–65	63–65
Abrasion loss	0·110	0·110
Fatigue flexing	268	over 1000
Per cent. swelling at 70 deg. Cent. in—		
Diesel oil	480	58
Transformer oil	275	15
Mobiloil BB	104	4

The figures given above deal with two comparable mixings. It must be appreciated that both neoprene and rubber can be compounded by the rubber manufacturer to give products of widely varying hardness, tensile strength, and resilience.

The ageing of rubber is usually assessed by determining the drop in tensile properties after varying periods of time in the oxygen bomb under 300 lb. per square inch pressure at 70 deg. Cent. or in the Geer oven in air at 70 deg. Cent. The following tables

† Contributed by B. J. Habgood, B.Sc., A.I.C., A.I.R.I.(Sc.).

give an indication of the comparative ageing figures of neoprene and natural rubber.

The resistance of neoprene to weathering, sunlight, and ozone is very great as compared with natural rubber.

TABLE II.—*Oxygen Bomb Ageing at 70 deg. Cent. at 300 lb. per square inch Oxygen Pressure.*

	Rubber			Neoprene		
	Tensile Kgs./cm.²	Elongation per cent.	Hardness	Tensile Kgs./cm.²	Elongation per cent.	Hardness
Unaged . .	216	625	60	224	602	68
6 days. . .	86	366	64	167	448	72
12 days. . .	34	132	83	157	378	74
18 days. . .	perished	perished	100	132	313	77

TABLE III.—*Geer Oven Ageing in Air at 70 deg. Cent.*

	Rubber			Neoprene		
	Tensile Kgs./cm.²	Elongation per cent.	Hardness	Tensile Kgs./cm.²	Elongation per cent.	Hardness
Unaged. . .	246	625	60	224	602	68
3 weeks . .	265	506	—	249	496	—
6 weeks . .	206	401	67	241	422	72
12 weeks . .	41	135	70	200	280	80

Bonding to Metal.—In engineering applications the bonding of rubber and related compounds to various surfaces, and to metals in particular, is of great importance, and several methods are available, many of which depend upon the deposition of brass on to the metal to be bonded. The technique of bonding is dealt with in detail in a paper by B. J. Habgood in *Trans. Inst. Rubber Industry*, XIII, 2, 136, 1937, which also contains an extensive bibliography. Neoprene can be bonded directly to brass and to a variety of metals including iron and steel, nickel, chromium, lead, zinc, and aluminium and its alloys, by the use of a chlorinated rubber interlayer (U.K. Pat. 493,139). Excellent adhesion is obtained equal to the strength of the neoprene itself.

Rubber is already being used as a protective covering for shafting, where its resilience and flexibility allows the covering to adjust itself to deformation without fracture. The protection of pipe lines carrying salt water, which is highly corrosive to nearly all metals, is a relatively new application and is proving highly successful, since not only is rubber very resistant to electrolytes—a fact adequately demonstrated by its successful utilisation in the chemical industry—but being an insulator it prevents the development of electric currents through galvanic action, the cause of much trouble in the past.

Shock and Vibration Absorption.—In the motor-car industry the use of rubber as a shock-resisting and vibration-damping suspension has come to stay. There would appear no reason why the same principle should not be applied with advantage aboard ships, not only to heavy reciprocating machinery but to electrical generators and other auxiliary gear tending to transmit noise and vibration through the hull. In submarines the efficient damping of noise would appear to be of paramount importance in lessening the risk of detection.

The superior oil resistance of neoprene enables resilient mountings to be employed under conditions where natural rubber would rapidly fail, and trials are in progress using neoprene suspensions for large marine Diesel engines and high-speed pumps. It is suggested that similar methods could be used for the prevention of hull vibration and metal fatigue in high-speed craft and for the alleviation of compressional strain developed in various circumstances. Under conditions where shock absorption, as distinct from vibration damping, becomes important, the higher hysteresis of neoprene makes it superior to rubber in applications such as gun-mountings and recoil mechanisms. The effective bonding of neoprene to metals renders possible the manufactured of laminated neoprene-metal sheets; these would be expected to show high shock-resisting properties and might find special applications in ship construction.

Neoprene Paint.—Before finally leaving the uses of bonded neoprene, reference must be made to a recent development which appears to be of great promise, namely, the application of neoprene solutions as protective coatings. Neoprene in its unvulcanised condition is considerably more soluble in organic solvents than is rubber; that is to say mobile solutions containing up to 30 per cent. of neoprene can be readily obtained which are capable of being brushed or sprayed on to various surfaces. One of the latest developments, which has been reported as being successful, is the lining of vortex chambers with neoprene paint. The heat encountered under service conditions vulcanises the material *in situ* with the result that corrosion troubles are stated to have been entirely overcome through the use of such coatings. Self-vulcanising solutions can be used if necessary, thus enabling the treatment of large areas which could not be vulcanised or stoved.

The investigation of neoprene paint as an anti-fouling composition would be of interest, and the production of non-slip deck coverings, having excellent ageing properties, would appear to hold great promise. It has been stated that the "Empire Day" speedboat, the unofficial world record holder 400 Kg. class, piloted by E. Spurr in September, 1938, was equipped with a neoprene-coated hull as a protection against erosion and corrosion. It has further been reported that propellers which have been treated with neoprene paint have given excellent results, the scouring effect of sand and the pitting caused by cavitation being largely eliminated.

Another interesting application of neoprene solution lies in its application in the construction of radiators, oil coolers, intercoolers, and the like in which neoprene replaces brazing and soldering, the resilient properties of the neoprene bond giving increased protection against the deleterious effects of vibration.

Oil-Resistant Products.—The resistance of neoprene to oil enables its successful use in a number of applications where rubber would fail, such as for oil seals and gaskets, including cork gaskets in which the cork granules are bonded together with neoprene, and for valve diaphragms. A good report has been received on the wearing qualities of neoprene air pump valves in resisting corrosion under oily conditions. The aeronautical industry has developed the use of neoprene strips for the caulking of joints where welding is inadmissible, and it is possible that a similar method may be of interest to the shipbuilder.

Large quantities of neoprene oil hose are at present being manufactured, the material being resistant not only to oil but also to weathering (a factor of particular prominence in the tropics) so that the problem of storing spares becomes much easier. The fact that neoprene hose can be manufactured with a smooth bore free from internal wiring is a further advantage, enabling higher flow rates to be obtained with a given diameter.

Electrical Equipment.—The superior ageing properties of neoprene render it suitable in a number of applications for which rubber is definitely unsuitable. The increased resistance to weathering and the possible use of neoprene as an anti-corrosive covering and also for deck covering have already been mentioned. Its use in unarmoured cable is at present attracting attention. At one time the greatest drawback to the V.I.R. cable lay in its relatively short life, which meant that vessels had to be refitted at least once during their life, but the improvements secured of late years through the use of organic accelerators and anti-oxidants combined with strict scientific control of manufacture have gone a long way towards overcoming this difficulty, and the life of armoured cables and lead-covered V.I.R. is to-day of a high order. In the case of unarmoured and uncovered flexible cables, where the effect of light plays an important part and where the cables are working under high temperature conditions (*e.g.* in stokeholds, engine rooms, &c.) the use of neoprene as a sheathing is of interest. It has been suggested that a great saving in weight could be obtained through the replacement of lead armouring by neoprene or similar products, and the suggestion would appear worthy of trial.

The electrical properties of neoprene are somewhat inferior to those of natural rubber.

TABLE IV.—*Comparative Electrical Properties of Rubber and Neoprene*

	Vulcanised Rubber	Vulcanised Neoprene
Volume resistivity Ohms./cm.³ ...	$1{\cdot}35 \times 10^{15}$	1×10^{15}
Dielectric constant	2·3	5
Breakdown strength Kv/mm. ...	30	10
Power factor (radio frequency) ...	2·1	8

The above figures are indicative of the differences between rubber and neoprene, but the actual figures will vary to some extent with the compositions of the mixings employed. Notwithstanding the relatively poor electrical characteristics of neoprene, satisfactory results have been obtained when using it as an insulator for voltages up to about 250. With higher voltages a rubber insulation protected by neoprene sheaths is usually employed. The production of conducting rubber sheaths by the incorporation of carbon black, &c. has recently attracted attention since static electricity is largely eliminated in this way and the leakages which give rise to so much corrosion trouble are largely overcome. Sheathings made from neoprene by a similar method give even higher conductivities.

Before leaving the question of electrical equipment a passing reference will be made to the use of hard rubber ebonite for battery boxes. Ordinary ebonite has been so used for many years and, while satisfactory in its resistance to electrolytes, it suffers from one grave disadvantage in that it is somewhat brittle under impact. By the introduction of relatively small amounts of neoprene a material known as "flexible ebonite" is obtained which retains the anti-corrosive properties of ordinary ebonite whilst giving markedly improved shock resistance. Experiments are actively proceeding in the development of flexible ebonite battery containers which, if successful, should find use in ships, particularly in submarines.

The covering of light alloy battery boxes with neoprene and with flexible ebonite is also being investigated, but the trials are at present incomplete. It is hoped that a great saving in weight will be obtained in this way.

Flame Resistance.—Undoubtedly a great drawback of vulcanised rubber lies in its inflammable nature. The need for fireproof materials in ship furnishing has been only too well illustrated by the disastrous fires which have destroyed many ships in recent years, and in fighting ships the utilisation of flame-resistant rubber becomes more important still. A great deal of work has been carried out recently on the subject of flame-resistant rubber and a survey of the subject is given in a paper by Dawson (*India Rubber Journal, 90*, 525, 1935).

In neoprene, however, we have a synthetic rubber which contains a relatively high percentage of chlorine—namely, about 40 per cent.—and after vulcanisation exhibits mechanical properties similar to those of natural rubber. Neoprene, therefore, is an excellent starting material for the production of flame-resistant and incombustible rubber articles, and neoprene mixings are readily obtainable which when held in a bunsen flame burn only with difficulty, and cease to burn immediately on removal from the flame.

Poly-vinyl chloride is another material of interest as a flame-resistant insulator for cables and similar purposes. This material contains approximately 50 per cent. of chlorine and its physical properties can be varied over a considerable range by the addition of plasticisers so as to obtain products varying from hard horny materials down to soft rubbery ones. Poly-vinyl chloride, however, has one disadvantage compared to neoprene in that it is thermoplastic and softens at about 70 deg. Cent. and cannot be vulcanised. It does, however, exhibit excellent resistance to ozone, to oil and to weathering, and in cases where no high temperature conditions are likely to be met with in service there is no doubt of its great potentialities.

It is hoped that the above summary of the properties of rubber and related products, and of their suggested applications, will interest and help naval architects and shipbuilders in the solution of some of their problems. It cannot be too highly stressed that close co-operation between the engineer and the rubber technologist is of paramount importance if the best results are to be obtained.

PAINTS AND FINISHES

Paints for Protection against Corrosion and Decay.—The use of paint materials in ships gives rise in the first place to certain general problems of protection which are common to other constructions also, and secondly to a great number of special problems of localised or limited interest which there will not be space to examine here. An example of the latter is the problem of corrosion in oil cargo tanks on which Mr. H. S. Humphreys made some illuminating remarks in his paper "The Care and Maintenance of a Modern Diesel-Engined Tanker Fleet" (Trans. Inst. Mar. Engrs., XLVIII, January, 1936).

In view of the references made below to decorative uses of paints it will be well to make clear, in first considering the use of paint for protective purposes, that the same paint may be both protective and decorative. The protection afforded by the film is due to the combined effects of the vehicle and pigment after air-drying or forced-drying, the degree of such protection depending to some extent upon the thickness of the film but mainly upon such of its properties as flexibility, resistance to heat, cold, and wet.

The problems that arise in connection with the protection against corrosion and decay can be conveniently examined under the following heads:—

(*a*) Anti-fouling (below water line).
(*b*) Other protection (above water line).

Anti-fouling compositions are directed against the adhesion of barnacles to the ship's bottom. It has not so far proved possible to devise means of preventing such adhesion, but only to reduce the amount of adhesion and to facilitate removal by scaling-off such barnacles as have adhered. The importance of effective anti-fouling composition lies in the fact that barnacles provide resistance to the passage of the ship through the water. Effective anti-barnacle compositions thus increase speed and

reduce fuel consumption, not merely in theory but quite substantially.

A further purpose of anti-fouling compositions is the important one of reducing the corrosion of the ship's bottom. In general, the ingredients used in such compositions to resist the barnacles are certain toxic metallic compounds which are intended to poison the barnacles and so cause them to drop off or to render their subsequent removal easier, and the ideal anti-fouling composition is one which poisons the barnacles and slowly "chalks" so as continually to present a toxic surface; in the absence of this chalking characteristic the anti-barnacle value of the composition becomes progressively weaker until the application is renewed. Consequently a high order of durability has not been found compatible with the most effective anti-fouling characteristics. Although some progress, along conventional lines, has been made by the relatively small number of manufacturers concerned in the manufacture of anti-fouling compositions, no revolutionary changes in formulation have been proposed and an important field of activity here awaits further attention by the chemist.

Other protective finishes are those applied to the hull, superstructure and miscellaneous surfaces. On passenger ships the hull paints employed are black, white, or one of many intermediate shades. The instinct of the shipowners has been against high quality materials and they have in the main been content with orthodox oil paints, asking only that the paint should last for a reasonable period. The reason for this attitude, and for the consequent lack of application in ships of those developments which have latterly been realised through research on paints in general, may be found in the circumstance that the principal merit of improved finishes which has to be relied on to outweigh their slightly higher cost per gallon lies in their greater durability and appearance. Generally, their economy depends on the fact that labour costs are lower because the durability is greater; but where, as is so often the case on board ship, the crew do the exterior painting when they would otherise be idle so that labour cost is not a separate factor, such saving is not necessarily realised.

In a few cases where a separate labour cost is thrown up savings have indeed been effected through the use of modern materials of a synthetic resin type and it is worthy of note that some of the largest United States liners are finished in synthetic resin hull paints. Superstructural painting, moreover, is usually undertaken by contract, and this gives an opportunity for superior paints to be evaluated and for labour costs to become clearly apparent.

In the case of both hull and superstructure paints the essential difficulties encountered are the same. In ships operating through wide variations of latitude the alternation of heat and cold affords one of the severest tests that any paint can be called upon to resist. Paint should provide essentially a flexible film; within limits this flexibility is a saving feature, but beyond those limits extreme heat alternating with extreme cold may easily lead to cracking. The company with which the author of this section is connected have been successful in developing modern synthetic finishes which stand up effectively to extreme cold or to extreme heat and which have withstood severe tests in both cold and hot climates; but where these extremes alternate on one and the same film it has to be admitted that an extremely difficult problem remains outstanding. To some extent this has been solved by the use of a synthetic vehicle and modern types of pigment.

Insofar as hull and superstructure paints undergo cleaning, this is normally done by simple washing down without any drying. The paints are, therefore, exposed to brine, in addition to which the pigment from which the colour is derived may be affected by hot sunshine active over long periods. In the case of hulls, bituminous compositions have been tried but without success; they tend, after several coats have been applied, to sag. It will be appreciated that hull paints are applied, coat after coat, without any intervening preparation of the surface as in the case of ordinary decorative painting; the protection is afforded not by one paint film but by the many which are superimposed on one another, until eventually all are stripped away together so that the process may begin over again. A normal paint system may vary between 4 and 10 thousandths of an inch in thickness and such a relatively thin film would offer little protection against the waves which pound against the side of the ship; hence the practice of building coat upon coat.

The method of application is an important factor in connection with protective paints and finishes. For the painting of the hull and superstructure there is no reason why spraying should not be used except for the considerable waste of material which would be involved when working under very exposed conditions. The commonest method of applying general protective paints to hull surfaces is still by the use of the Turk's head brush.

Every ship contains a large number of miscellaneous items of one type or another which require protective painting; canvas and cordage are examples on which tar and bituminous type paints have been found satisfactory. Again, a very general problem of construction and maintenance is the prevention of rust, a problem which, during the building of the ship on the stocks, is met to some extent by the use of a rust-inhibiting primer.

Paints for Internal Structure and Decoration.—Science and art are no longer thought of as incongruous. The chemist's contribution is a scientific one, but is none the less artistic as well. This is especially true in the decoration of ships, where the chemist plays an essential though indirect part in æsthetic realisation. Nor should this function be construed too narrowly in terms of the pleasure afforded to passengers alone; for, just as it has now been established that factory operatives react favourably to a bright environment, so there are signs of a disposition on the part of shipbuilders and shipowners to perceive that (subject to over-riding economic considerations) the accommodation provided for ships' crews need not be so drab as has often been the case in the past. Owners, in providing the brighter atmosphere to which paint can so largely contribute, may not only give themselves pleasure as employers but are likely to influence helpfully the attitude of the crew to their several tasks. This applies to cargo vessels no less than to passenger ships. Here two sciences meet, for the chemist is helping to implement the work of the industrial psychologist.

The contribution made by the paint chemist to the decoration of the modern ship is best summarised by indicating the principal developments in paint formulation which have taken place in recent years. The basis of orthodox paints was always drying oil in which pigment was ground. Even before the revolutionary changes in composition which have occurred in recent years the contribution of the chemist was far from insignificant, for there are many grades of oil paint and the adjustments which can be made to ensure the complete suitability of the product for the particular purpose in view are the result of much patient investigation on his part. It would be unsound to assume, because new types of finish have in many instances displaced oil paints, that these have had their day or are incapable in appropriate circumstances of giving eminently satisfactory results. Here, as elsewhere, enthusiasm for technical advance needs to be tempered by a reluctance to identify the new with the invariably and necessarily better.

Chemical research, again, has been responsible for the development of methods of producing cellulose acetate and cellulose nitrate from vegetable material. Both in the United States and in this country it was realised that the products so available might, with suitable solvents, be used to provide a film for coating both metal and wood surfaces. The adaptation of nitrocotton to such peaceful purposes as the manufacture of finishes provides a notable example of the sword being beaten into a ploughshare. Faster drying and the possibility of spray application are two of the principal advantages derived from nitrocellulose finishes which have led to their use becomng all but universal in the mass production of motor cars and furniture. Still newer materials continue to be developed, offering, for particular purposes, still further advantages.

In their decorative applications cellulose finishes gained ground slowly, mainly owing to the difficulty, in the case of small jobs, of making the spray equipment available on the site, and also to that of masking in cases where only small areas are to be finished. As regards interior finishing of passenger ships there has been no difficulty at all, and cellulose has in fact made an important contribution to the interior decoration of the woodwork of modern vessels.

The latest and most revolutionary material in this field to become available through the work of the chemist is that resulting from his formulation of finishes with synthetic resin vehicles. These have provided paint films greatly superior in important respects, including those of durability and flexibility, to orthodox materials of the oil type, and also much superior in build to the best nitrocellulose finishes. Gloss is readily regulated by small adjustments in formulation and the materials are normally available in matt, eggshell and glossy types.

Another recent development, the applications of which are being studied and may well prove to be of special interest in marine work, is the incorporation in paints of the chlorinated rubber already mentioned in this paper. One of the special merits of this procedure lies in the proved possibility of thereby obtaining a paint which offers considerable resistance to flame and which can be used with advantage for the serving of electric cables and the covering of tanks for inflammable liquids. In addition it is highly resistant to corrosion, and experiments are being made to test its anti-fouling properties.

Gear Powders*

Many methods, such as casting, forging, rolling and extrusion, have been used to coax metals into the shape that is finally desired. In the past decade a new method, the compression of metal powder, has been added to the list and now forms the basis for a growing industry. Simplicity of fabrication is not, however, the sole reason for the increasing interest in metal powder technology. The powder method may be used to alloy metals which will not ordinarily alloy, to obtain greater accuracy of composition in the final product, to produce a porous final structure or to obtain many other qualities not possible with the continuous metal. Bars or rods compressed from metal powders can be worked to obtain sheets, wires, and similar products with a close, uniform structure.

Almost all of the metals are now obtainable as powders, though of course at a wide variation in price. In general the powders are substantially more expensive than the corresponding solid metals and can be used only when processing economies offset the extra cost of the raw material. However, in the production of small, simple parts the speed of production and the savings in material occasioned by the elimination of machining often make the use of powder less expensive than the conventional use of the metal.

Many alloys are made by mixing their components in powder form. Stainless steel, for instance, may be produced by mixing iron, nickel, and chromium powders, although it is necessary to heat-treat the product for a relatively long time and at a high temperature to disperse the three constituents. Brass powder is produced by heating a mixture of copper and zinc powder to a temperature close to the melting point of zinc. This is a diffusion method. Mixing the powders is not, however, a simple procedure; and, where there is a great difference in density between the materials to be mixed, it may require up to three or four days. Of late equipment has been developed which reduces the mixing period considerably.

An outstanding current problem in the art is the production of ferrous alloy parts which will have the hardness required in many uses. Ferrous alloy powders meeting the hardness requirements have offered serious moulding difficulties. One solution to this dilemma has been to decarbonise the surface of the particles, thus producing a coating of soft iron, which permits the cohesion and welding of the powder under pressure. After forming, the product is heated and the carbon disperses uniformly, yielding a product of requisite hardness and having an unusually high tensile strength. This work opens a broad new field.

Probably some of the greatest advances in the utilisation of metal powders have been in mould design and in the moulding process. The quantity of powder delivered to the mould must be kept constant within minute limits in order to produce products which are accurately uniform. So successfully have the orifices through which the powder flows been designed that it is now possible to produce gears and other parts which require no further finishing. It has been determined that the shape of the particles, their size, assortment, and the apparent density have an appreciable influence on flow and that consequently great care must be exercised in the production of the powders. The fine powders, of course, contain large quantities of air which must be vented during the moulding operation. The design of the vent, which must pass air but hold back particles sometimes finer than 400 mesh, has been a vexing problem but has been solved. Despite the difficulties encountered originally, production rates up to 1500 parts per minute on a single press have been attained for simple parts, far exceeding the moulding rate for plastics but not yet equalling that of pharmaceutical tablets.

Formation of large articles by moulding is difficult, for the total pressures required become impracticably large. Aside from the increased cost encountered with high pressure, the size of the press becomes unwieldy, since the powder occupies three times the volume of the final product. Handling of such large volume requires elimination of a large quantity of air and demands impracticably close control of friction in order to secure dimensional accuracy. It is now possible, however, to fabricate larger articles from strips formed by compressing the powder either alone or on to a solid base sheet. Some investigational work is now being conducted on compression under vacuum, whereby the required pressures may be reduced from 30 tons to some five tons per square inch.

The parts formed from powdered metals have diameters of up to eight inches; commutator rings are a good example. Gears, brake drums, and clutch rings are typical products. Powder compression may be used to particular advantage in annular parts, since so much material is normally wasted in cutting the rings from sheets. The versatility of powdered metal products is well demonstrated by the use of a sheet made from aluminium powder on the leading edge of an aeroplane wing to prevent ice formation. The pores may be filled with wax, which prevents adhesion of the ice, or a liquid may be forced under pressure through the pores to prevent ice formation. The continual progress in mould design, the better appreciation of the factors involved in producing a satisfactory powder, and the advances in the utilisation of iron powder combine to indicate greatly increased usefulness for metal powders in the future.

* From Arthur D. Little, Inc. Industrial Bulletin, Jan., 1940.

Rail and Road

MEXICAN RAILWAY ACCIDENT.—When a passenger and a freight train collided head on south of Queretaro City recently, twenty persons were killed and an unknown number injured.

ROAD VEHICLES: NEW REGISTRATIONS.—The number of mechanically propelled road vehicles registered for the first time in Great Britain during the month of January, 1940, was 11,746 compared with 40,001 in January, 1939.

SOUTHERN RAILWAY MISHAP.—When the 8.7 a.m. train from Shoreham-by-Sea was leaving Cliftonville tunnel on Wednesday, February 28th, it ran into and was derailed by a fall of chalk. Although the train was crowded with passengers not one was injured. Both lines were blocked for some time and trains were diverted to another route.

ARGENTINE RAILWAY IMPROVEMENTS PROGRAMME.—An expenditure of an additional sum of nearly three million dollars has been authorised by the Argentine Government on railway improvements. Of this amount nearly two million dollars will be spent on line repairs and equipment, 360,000 dollars on the Parana-Rio Grande line and 230,000 dollars on the reconstruction of the Transandine Railway.

NEW TRAMS AT GLASGOW.—A scheme for the construction of four-wheel trams, similar to two experimental vehicles built at the Coplawhill works, has been placed before the Glasgow Transport Committee. The experimental cars cost £2946 and £3140 respectively, and it is anticipated that a large sum of money will be saved if the scheme is adopted. The new vehicles have separate driving compartments and incorporate improved braking facilities.

AMERICAN RAILWAY INCOME IN 1939.—Statistics of the Bureau of Railway Economics of the Association of American Railroads show that the Class 1 railroads of the United States had a net operating income of nearly 600 million dollars or a return of 2·26 per cent. on their property investment in 1939. Gross operating revenues totalled nearly 4000 million dollars and operating expenses nearly 3000 million dollars. Taxes paid amounted to nearly 400 million dollars.

L.M.S. NEW TURNTABLES.—The London Midland and Scottish Railway Company announces that at nine out of ten places where locomotive turntables are to be renewed, the new turntables will be of larger diameter so as to accommodate bigger locomotives. The places affected are Bolton, Colne, Burton, Chaddesden (Derby), Nottingham, Shrewsbury, Tebay, Penrith, Normanton, and Stranraer, and with the exceptions of Burton (57ft.) and Shrewsbury (70ft.), all the new turntables will be of 60ft. diameter; some of those to be replaced are as small as 42ft.

NEW MEXICAN LINES.—When a 460 miles long railway now under construction between Puerto Mexico and Campeche is finished the United Railways of Yucatan will be connected with the National Mexican Railways system. In the north-western part of the country a line is being laid between Fuentes Brotantes and Santa Ana on the system of the Southern Pacific of Mexico, and when it is completed it will be possible for goods to be sent from Lower California to the Mexican markets without the necessity of passing through the United States. On both these lines the problem of obtaining suitable boiler water for steam locomotives is particularly acute, and it has been decided to use oil-electric locomotives for both shunting and train haulage.

GOODS VEHICLES RUN ON GAS.—The present basic ration of liquid fuel fixed by the Minister of Transport for goods vehicles run on producer gas is one-sixth of the normal issue. It has now been increased to one-half of the normal issue, and the same proportion will be available for vehicles running on coal or other gas, whether in cylinders or loose containers. The new arrangement will remain in operation for six months. There will be a review of the position before the end of this period. The new arrangement will not affect the existing right of operators of vehicles propelled by gas to apply for supplementary rations of liquid fuel for approved work for which gas propulsion is unsuitable. The Minister hopes that under this arrangement operators converting their vehicles will be able to derive the fullest possible benefit from their enterprise, and that others will be encouraged to follow suit.

VEHICLES FOR CIVIL DEFENCE.—The Civil Defence and General Purposes Committee of the London County Council reports that the hiring charges for the 7800 vehicles mobilised by the council for its civil defence services would amount to over £310,000 in a year. The Government has recently indicated that it is desirable to discontinue the existing hiring arrangements as soon as possible and purchase second-hand vehicles for use in the civil defence services. This policy will involve the purchase of more than 4000 motor-cars, lorries, vans, and motor-cycles, at a cost of some £205,000. Second-hand cars purchased for the Auxiliary Ambulance Service are already being converted into light ambulance vehicles at the rate of 50 a week. As converted cars become available to tow trailer pumps for the Auxiliary Fire Service the taxis which have been used for this purpose since the beginning of the war will be returned to their owners.

ROAD IMPROVEMENT PROGRAMME IN SPAIN.—An extensive scheme has been prepared for the reconstruction and extension of the road system in Spain. The first part of the scheme, which has been begun, includes the reconstruction or repair of roads and engineering structures, the construction of new roads and the completion of work previously begun. Concrete or bituminous surfacings will be provided on first- and second-class roads, water-bound macadam being used on rural roads only. On first- and second-class roads level crossings and curves of small radius will be eliminated. It is expected that this work will be completed in four or five years. During the second period 390 miles of national roads, 1250 miles of provincial roads, and 6250 miles of rural roads will be constructed, the respective widths being 30ft., 25ft., and 20ft. At the end of this period Spain will possess a total of 12,165 miles of national, 15,000 miles of provincial, and 62,500 miles of rural roads.

Miscellanea

COAL EXPORTS.—Exports of coal from this country in January showed a rise in value of £452,846 at £3,472,012 compared with £3,019,166 in the same month of 1938. Shipments of coke and manufactured fuel declined by £54,341 to £349,773 as against £404,144 in January last year.

A LONG SWEDISH ROPEWAY.—A ropeway at present under construction in Central Sweden will have a total length of about 26 miles. It is to be used for the transport of limestone, its capacity being about 90 tons an hour. The cost of the plant, which is expected to be completed by the end of the year, is estimated at £235,000.

INSTITUTION OF NAVAL ARCHITECTS.—It is announced that the annual general meeting of the Institution of Naval Architects will take place in the Lecture Hall of the Royal Society of Arts, John Street, Adelphi, W.C.2, on Wednesday, March 13th, at 11.30 o'clock. At this meeting, members are reminded, only formal business will be transacted, and this will include the annual report of the Council, election of president, vice-presidents, treasurers, and officers and council, election of new members, associate members, associates, and students, and the appointment of scrutineers for the next annual meeting. No annual dinner is to take place this spring. A list of the papers which have been selected for publication in this year's volume of the Transactions is herewith appended, and advance copies of these papers may be obtained from the secretary. Written comments thereon are invited with a view to their publication in the Transactions. The papers are as follows—"The Shipbuilding and Ship-repairing Industries After the War," by Sir Archibald Hurd; "Ship Structural Members," by Mr. J. L. Adam; "A New Method of Calculating Wave Profiles, and Wave Resistance of Ships," by Dr. Rene Guilloton; "Rolling Experiments with Ships and Models in Still Water," by Mr. R. W. L. Gawn, R.C.N.C.; "Some Experiments with a New Instrument for the Measurement of Heel and Trim," by Mr. T. U. Taylor; "Longitudinal Strength," by Mr. J. Foster King and Mr. J. Turnbull; and "The Salvage of H.M.S. "Thetis," by Mr. G. R. Critchley.

THE BRITISH CORPORATION REGISTER JUBILEE.—At the fiftieth annual meeting of the British Corporation Register of Shipping and Aircraft, which took place in Glasgow on Wednesday, March 6th, the chairman, Mr. Gilbert J. Innes, said that the meeting had an importance of its own as it marked the Jubilee of the British Corporation Register. Reviewing the origin and progress of the Corporation's work during the past fifty years, Mr. Innes said that the history fell broadly into two stages, first an initial stage during which the Corporation successfully achieved its primary motive of combating monopoly in British control of load lines and classification, and a later stage of remarkable growth from national to international influence in both spheres of activity. On the technical side the Corporation had to its credit the approval of the design for the first Isherwood oil tankers, and for large single deck craft for bulk cargoes. It also sponsored the introduction of topside tanks and stringerless ships, of double bottoms with open floors, of wide-spaced pillars in holds, as against rows of stanchions, while linked up with this development were the large unencumbered hatches of the modern cargo liner. Outstanding ships had included the first ocean-going turbine steamer "Loongana" and the first Atlantic motorship "Jutlandia," which had been followed by many notable ships and the more recent aircraft developments connected with the register. The raison d'etre of the British Corporation was the need to create high standards of technical excellence, capable of commercial application. This had been the justification for the Society's existence and progress during the past fifty years, and it must be the continuous aim of the Corporation in the years which were to come.

ANGLO-FRENCH TRADE TALKS.—This week, at the headquarters of the Federation of British Industries, there were held a series of meetings between leading British and French industrialists for the purpose of discussing economic and commercial problems of common interest. These meetings were referred to in Journal Notes in our issues of February 16th and February 23rd. A full list of delegates is now available. From France there are:—M. René Duchemin, chairman, la Confédération Générale du Patronat Français, president, Etablissements Kuhlmann, vice-president, International Chamber of Commerce; M. Marlio, president, la Compagnie des Mines et Produits Chimiques d'Alai, Froges et la Camargue; M. Henri de Peyerimhoff de Fontenelle, president, le Comité Central des Houillères de France; M. Painvin, vice-president, la Chambre de Commerce de Paris, president, l'Union des Industries Chimiques; M. Dubrulle, president, la Fédération Internationale de la Laine; M. Jacquet, member of the executive council, le Syndicat Général de l'Industrie Cotonnière; M. Alfred Lambert-Ribot, vice-president, le Comité des Forges; M. A. Dutreux, vice-president, Fédération de la Mécanique; M. Detoeuf, president, le Syndicat Général de la Construction Electrique; M. Bienaime, president, l'Union des Syndicats de la Parfumerie; le Vicomte de Lavergne, deputy vice-president, la Confédération Générale du Patronat Français. The British delegates are:—Lieut.-Colonel Lord Dudley Gordon, president-elect of the Federation of British Industries, chairman, J. and E. Hall, Ltd., Dartford; Lord Barnby; Sir Francis Joseph, chairman and managing director, Settle, Speakman and Co., Ltd., Stoke-on-Trent; Lieut.-General Sir George Macdonogh, chairman, International Paint and Compositions Company, Ltd.; Sir George Beharrell, chairman, Dunlop Rubber Company, Ltd.; Sir William Larke, director, British Iron and Steel Federation; W. J. U. Woolcock, Imperial Chemical Industries, Ltd.; Captain D. Bulay-Watson, chairman and joint managing director, C. F. Taylor and Co., Ltd., Shipley; Forrest Hewit, chairman, Joint Committee, Cotton Trade Organisations, vice-chairman, Calico Printers' Association, Ltd.; A. C. Macdiarmid, chairman and managing director, Stewarts and Lloyds, Ltd.; Guy Locock, director, Federation of British Industries; C. F. I. Ramsden, foreign director, F.B.I.; Roy Glenday, economic adviser, F.B.I.; Philip Archer, French representative, F.B.I.

Air and Water

INDEPENDENT AIR SERVICES.—The Government has notified a number of independent air services in this country that the national air communications scheme under which they have been working since the beginning of hostilities is to be concluded, and their aircraft taken over. The companies concerned have prepared a scheme, which they are seeking to place before the Air Ministry, which they think would help them to survive and also help the country.

CONTROL OF SHIPBUILDING AND REPAIRS.—The Controller of Merchant Shipbuilding and Repairs has appointed Mr. S. M. Turnbull of the Greenock Dockyard Company, Ltd., and the Clan Line, Ltd., and Mr. Summers Hunter of the North Eastern Marine Engineering Company, Ltd., to be his personal representatives for Scotland and Northern Ireland and for North-East England respectively, with the title of "Regional Director." Both these gentlemen have agreed to give their services.

CANADIAN-BUILT FIGHTER AIRCRAFT.—The first "Hurricane" fighter aircraft to be built in Canada has arrived in England. It was built by the Canadian Car and Foundry Company and is the first of a series of similar machines which will be delivered in the near future. The constructors form part of the group of factories carrying out the orders for aircraft placed by the United Kingdom Government with the Dominions. Built to normal British specifications, the machine has already carried out a satisfactory test flight in Canada.

RIVER IMPROVEMENT IN AMERICA.—During the Great Lakes navigation season, the steel plants at Cleveland, in the United States, are served by vessels which sail up the Cuyahoga River. In 1938 work was begun on the improvement of this river by straightening out its crooked channel in order that the boats, which are about 635ft. long and 70ft. beam, could save time on the up-river trip. Points which jut out are being cut back, the principal bends are being eased, and a number of old narrow bridges are being widened to provide a channel generally not less than 200ft. wide at the main unloading docks. Three new highway bridges with quick lifting spans are under construction and two basins for turning the boats are being provided. The work will cost just under 14 million dollars.

NEW AMERICAN MOTORSHIP.—The first of the C-3 type motor cargo ships being built under the United States Maritime Commission has been placed in service. Named the "Mormacpenn" the new vessel has the following main dimensions: length overall 492ft.; breadth 69ft. 6in.; depth of shelter deck 42ft. 6in.; deadweight 11,735 tons. Propulsion is by four two-stroke oil engines rated at 2225 B.H.P. at 240 r.p.m., having a maximum continuous rating of 2450 B.H.P. at 247 r.p.m. Each pair of engines is connected to one pinion of a reduction gear, with an electro magnetic coupling interposed between each engine, and the pinion it drives. The gear ratio is such that, when the engines are turning at the rated speed of 240 r.p.m., the propeller speed is 85 r.p.m. Each engine has seven cylinders 20¼in. diameter by 27¼in. stroke.

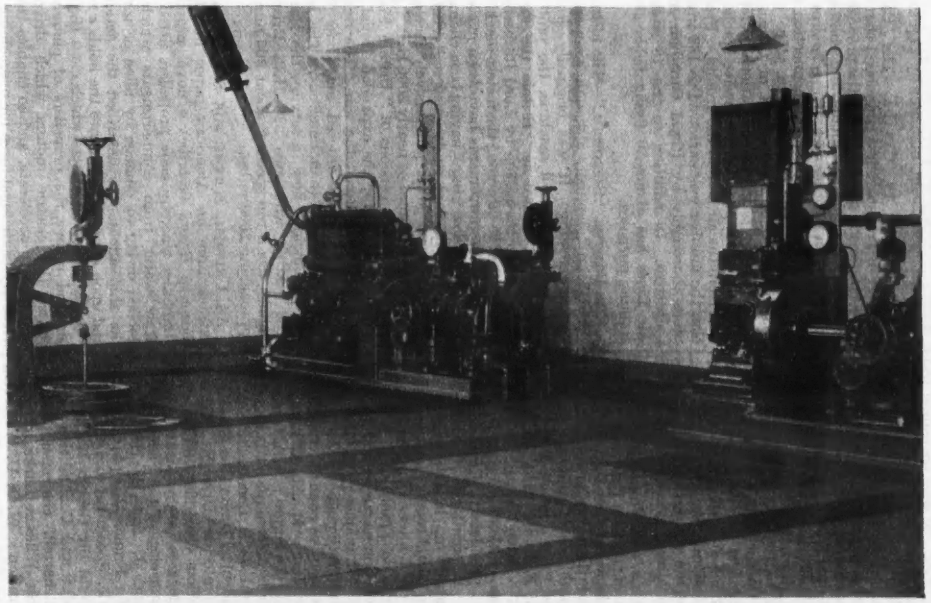
AERODROMES IN CANADA.—The Canadian deputy Minister of Transport has announced that detailed surveys have been made on 52 sites for the proposed establishment of flying fields across Canada and contour surveys have been made on 26 other sites. These 78 sites will probably be developed into flying fields in connection with the British Commonwealth air training plan. The fields are among 183 examined by department of transport officials and reported on by officers of the National Defence Department. Originally 1647 possible sites received preliminary examination from the air and on the ground. From this examination the number was narrowed to 183 which were studied more thoroughly by Royal Canadian Air Force representatives. In addition to the 78 sites, Trans-Canada Air Lines has about 30 flying fields also available for training purposes.

THE BRISTOL "BLENHEIM."—The history of the Bristol "Blenheim" bomber, although comparatively short, is very interesting. It was originally designed some six years ago as a civil machine, the prototype being the Bristol 142, known as "Britain the First," which was presented to the nation by Lord Rothermere after it had proved itself to be among the fastest machines in the world. A series of improvements have been made to the original design, the "low wing" having been changed to the "mid-wing," the fuselage re-designed and visibility improved, and the engine power progressively increased from about 1200 H.P. to a total of nearly 2000 H.P. An order in 1935 for 200 modified versions of "Britain First" laid one of the foundations for the expanded Royal Air Force with which Britain entered the war. The number of "Blenheims" eventually ordered may now be reckoned in thousands rather than hundreds. The latest version of the "Blenheim" now in service, the Mark IV or "long nose" fitted with two 920 H.P. Bristol "Mercury" engines, has a top speed of about 300 m.p.h., and a range approaching 2000 miles.

AN UNUSUAL SCHEME FOR SALVAGING VESSELS.—An extract from an American paper in *Shipbuilding and Shipping Record* describes a novel proposal by Mr. D. Hotchkiss whereby cone propellers fitted to cargo ships draw water from compartments which have become flooded owing to damage by mine or torpedo and keep the ship afloat. As described the action is automatic and upon entry of water into the holds a number of small "floats" release shutters which close the inlets from the sea and relieve the propellers of pumping load. This causes the electric motors which drive the rotating impellers to accelerate, and so enables them to give the necessary centrifugal force for overcoming the large head, or pressure of water due to the vessel's draught, and enables the propellers to commence pumping out the ship. A non-return valve gives the connection required, and when the leak is overcome the shutters—obeying the falling floats—regain their original positions. The description in *Shipbuilding and Shipping Record* concludes with the following remark, "The proposal is interesting. What we now want is an invention to ensure that such a vulnerable contrivance in such a vulnerable part of a ship will not be itself put out of action by a mine or torpedo."

OIL ENGINE RESEARCH LABORATORY

(*For description see page 236*)



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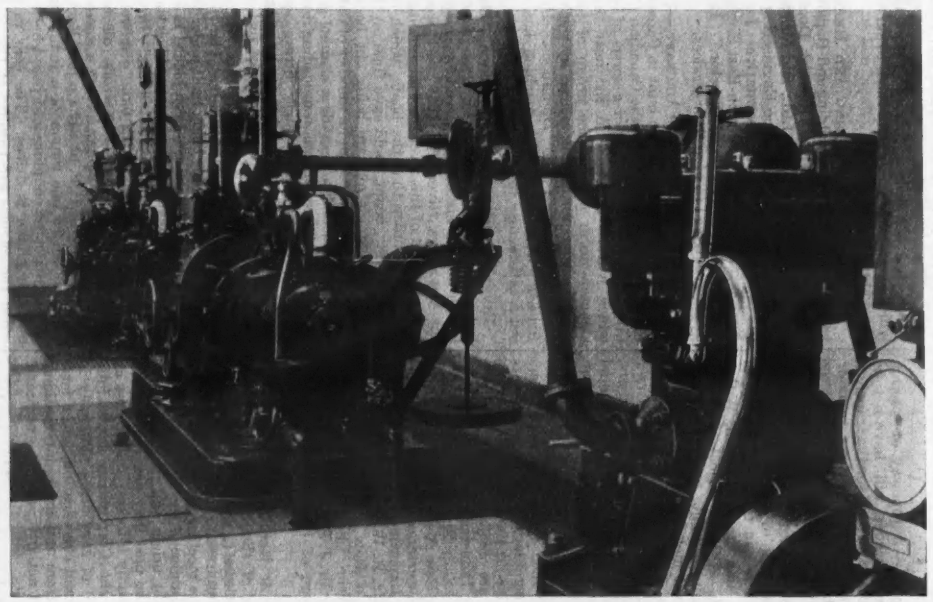

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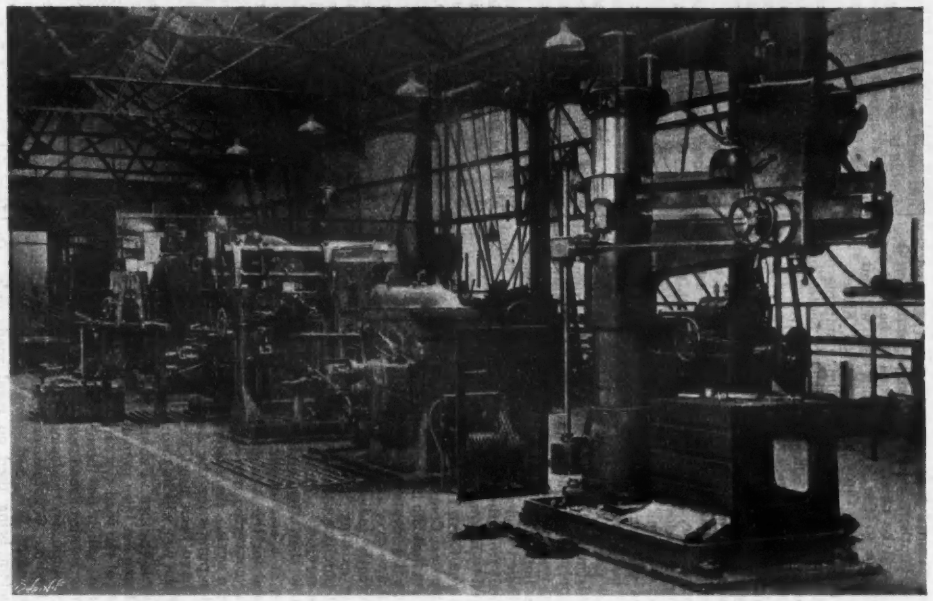
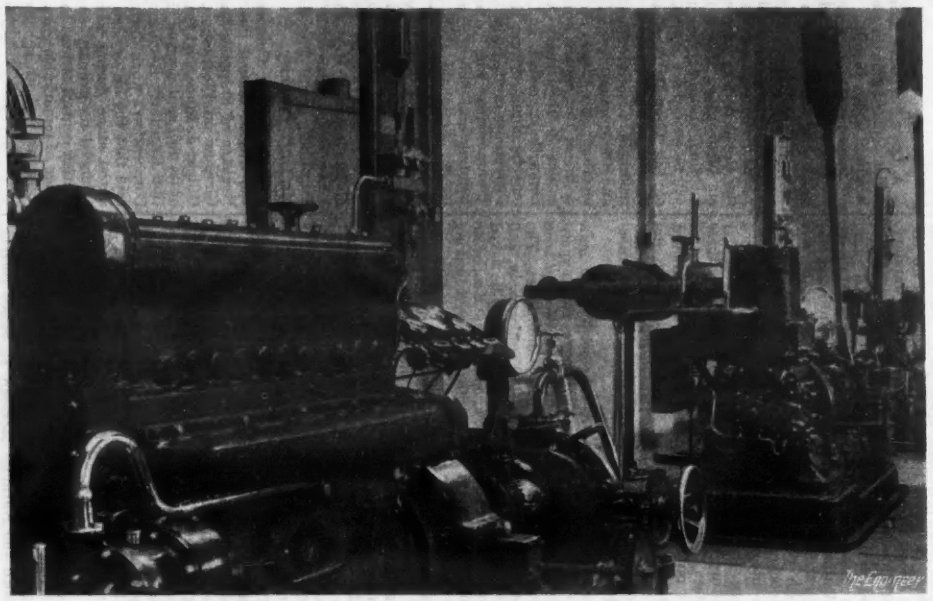
SIX-CYLINDER AND SINGLE-CYLINDER ARMSTRONG WHITWORTH ENGINES



LABORATORY WORKSHOP



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PUBLISHING AND ADVERTISING

THE ENGINEER is now being published at the works of William Clowes and Sons, Ltd., Beccles, Suffolk. Telephone No. Beccles 2103. All correspondence connected with publishing and advertising should be directed to that address.

EDITORIAL

All Editorial correspondence is being conducted from 28, ESSEX STREET, STRAND, W.C.2, and all articles, etc., should normally be sent to that address, but in cases of urgency messages may be sent to the Editor at Beccles.

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THE NAVY

IT is as certain as the hypothenuse that the speech which the First Lord of the Admiralty made in the House of Commons on Tuesday, February 27th, will not be circulated in Germany, unless the R.A.F. takes pains to distribute it in the Wilhelmstrasse and Unter den Linden. For, since nearly every word in it gives heart to the Allies, it could do no less than depress the enemy. Mr. Churchill is invariably encouraging and even when he has to record mishaps, misadventures, and tragedies, he places them in the right perspective, letting his countrymen and their allies know that the losses we suffer, and must suffer if we are to be about our business, are negligible by comparison with our ever increasing power and with the duties that the Navy is ceaselessly performing. Moreover, his candour inspires trust. No doubt he keeps some things back that it would be imprudent to say, but there is no Minister of the Crown who takes the public more into his confidence, none who more clearly sets before it both sides of the balance sheet. Whilst he displays proudly the great work that is being achieved by the Admiralty, the Navy, and all those who are working for and with them, he does not attempt to conceal our losses or to magnify the losses of the enemy. Hence it comes about that no Minister's speeches are more eagerly awaited and none more valued by the public.

The occasion of Mr. Churchill's speech was the consideration of the Navy Estimates. It may be that twenty-five years ago the Estimates were as short as those presented last week, but when we recall that we were able to cover them in a Journal Note in our issue of last week it will be understood that they revealed little or nothing regarding the building programme of the Admiralty. The votes, as the First Lord said, were only token votes, for in the first place it was physically impossible to make exact estimates for contingencies which were constantly changing, and in the second, there was no need to tell the enemy more than was good for him about what we were doing. But Mr. Churchill was able to indicate in some measure the magnitude of the work that is being pressed forward. He reminded the House that there are no modern battleships in service; many are being built in various countries, but not one is in commission. "In a short time," however, the British fleet will be reinforced by five ships of the King George V class, against which the enemy can only show two. We have, even now, three, if not four, possible lines of battle not one of which the German navy could face. In another very important direction the Navy is being augmented. It is expected that the U-boat campaign will increase as the summer approaches, and it is essential that counter measures should be pressed forward as rapidly as possible. Hence, the token estimates provide for the construction of a large number of vessels especially designed to combat this danger. Then there is the magnetic mine. The methods of attack upon U-boats have proved so successful that they have been practically forced to give up using their guns and have been largely driven from using the torpedo to the laying of mines in the approaches to our harbours. Here we must quote the First Lord's own words. "There are," he said "two stages in the process of dealing with the magnetic mine. The first is finding out what to do, and the second is applying this knowledge to practical conditions upon a very large scale. We are now far advanced upon the second stage, and although we must expect, perhaps in the immediate future, further much heavier attacks upon us by this method, we believe that we shall find ourselves equipped to deal with them." It would be improper even to hint at the nature of the counter measures which are being taken, but it is no secret that special equipment is being made in large numbers.

On the subject of modern warship design, Mr. Churchill gave some instructive and encouraging information. He reminded the House that all our existing major ships being of old design were liable to suffer from the advances which had been made with the torpedo and aerial bomb. Where one torpedo with a 500 lb. head was fired in 1915, now six, with much heavier charges, may be fired in a volley. This has necessitated the re-design of under-water protection, and the new "Lord Nelsons" which will soon be in commission are far better adapted to withstand under-water explosion than any ships we have at this time. Nevertheless he told his hearers that when H.M.S. "Barham"—a battleship of 1914—was hit by a torpedo she managed to get home under her own steam, and will soon rejoin the Fleet. He revealed also that a younger ship, but still fifteen years old, H.M.S. "Nelson," had suffered from an underwater explosion—a magnetic mine—but had been able to proceed under her own power. That was in the early part of December, and she will soon be ready to put to sea again. These are encouraging facts; they show that the bulge and other means of underwater protection even of our older ships are reasonably effective. We need not say that the case of the "Royal Oak" was exceptional. She was at rest and was struck by several torpedoes in succession. Unfortunately, it would appear from a remark by the First Lord that she has made Scapa Flow inaccessible for the present. That has meant that ships have had to keep at sea throughout a particularly severe winter more than they would have done in other circumstances. This fact led Mr. Churchill to pay a compliment to engineers that we feel it only right to put on permanent record in our columns. Speaking of our ships, he said, "their steaming capacity and the trustworthiness of their machinery is marvellous to me, because the last time I was here one always expected a regular stream of lame ducks from the fleets to the dockyards with what was called "condenseritis" or heated bearings, or other mechanical defects. But now they seem to steam on for ever. Even ships with old engines, under modern care, have steamed ninety days or more out of 119 days between the outbreak of war and the New Year. This reflects the very greatest credit on the engineering branch of the Royal Navy, and I wish to pay my tribute to them here in the House of Commons, and ask the House to join me in it, so that these many thousands of faithful, skilful, untiring engineers may learn, as they will learn, that we here in London understand what they have done and are doing, and that we admire their work and thank them for it."

Let us turn now from the Fleet itself to what has been accomplished by it, with the assistance of the air forces, in countering the efforts of Germany to impede our seaborne trade. That, it will be remembered, is at the moment the principal duty of the Navy. Even the destruction of the "Graf Spee" was not a naval action fought with the intention of diminishing the might of the enemy so much as the removal of a raider. The ceaseless warfare against U-boats is to be regarded in the same light. Whilst it is a fact, as we have seen, that they do now and then attack ships of war, their prey is the merchantman—regardless of nationality. Hence, it follows that the British and French Navies are performing the duty of policing the seas rather than engaging in battles. In this duty they have been as successful as could be hoped. By the end of last year the Germans had lost half the fleet of submarines, seventy in number, with which they began the war. The Admiralty estimated that ten new boats were commissioned so that the present year opened with a total of forty-five under-water raiders. It seems probable that ten of these are in operation at any one time, and the indications are that at least two are destroyed per week. With the completion of the programme of the new anti-U-boat craft referred to above it is hoped that the Navy will be in a position to meet any larger attack which Germany may have in contemplation.

It is fitting that we should end this review of the First Lord's speech with another literal quotation. In his peroration he said, "when we consider the great number of British ships which have been withdrawn for naval service, or for the transport of our armies across the Channel or across the globe, there is nothing in these results which—to put it mildly—should cause despondency or alarm, or which justifies the idea that we cannot carry on our national life and the war upon which our national life is centred, with increasing vigour. Any

reductions and austerities in home consumption, which we have found or may find it necessary to impose upon ourselves, are not due to any failure of the Navy to keep the seas pen, but to the need of making prudent preparations against the unknown, and of our raising our war effort to the highest pitch." It would be difficult to find any words which would express more concisely what the British Navy has accomplished and is accomplishing. For six months it has kept the seas open to commerce, and enabled the ships of all lands not only to transport hundreds and thousands of men and women, but to bring to our ports such vast supplies of overseas products that we suffer no appreciable privations, and to carry hence a volume of exports equal to that of peace time. That there have been grave losses is admitted, but on the other hand there have been notable gains and the enemy has not succeeded in reducing our sea-borne commerce in an appreciable degree. We owe that to the Royal Navy and to all those who, in greater or lesser duties, have helped to maintain the sea-tradition of this island and her empire. And we owe it no less to the engineers ashore who by their industry and skill and their increasing endeavours to make the ships of the King better than any other ships the world over, have given to the Navy material which is worthy of the great and enduring hearts which use it for the discomfiture of the enemy.

Obituary

SAMUEL MATTHEWS VAUCLAIN

ON February 4th, Mr. S. M. Vauclain died at the age of 83, at his home in Rosemont, Pennsylvania. He had been associated with the Baldwin Locomotive Works since 1883, and had been the chairman of its board since 1929.

Vauclain was born at Philadelphia on May 18th, 1856. Shortly after his birth, his father, Andrew Vauclain, formerly in the employment of Matthias W. Baldwin, the founder of the Baldwin Works, entered the service of the Pennsylvania Railroad and removed to Altoona. There the son was brought up in a railway atmosphere, and at the age of 16 entered the Altoona shops of the Pennsylvania Railroad as an apprentice. At the age of 21 he was appointed foreman of the frame shop. In 1882 he was sent to the Baldwin Works to inspect some locomotives then being constructed for his railway, and as a direct outcome was offered a position in those works. In July, 1883, he entered the company's service as superintendent of its Seventeenth Street Shops. Three years later, at the age of 30, he was appointed general superintendent of the plant. In 1896 he became a member of Burnham, Williams and Co., at that time the proprietors of the works. In 1911, the company having been incorporated as the Baldwin Locomotive Works, Vauclain was made a vice-president, becoming senior vice-president in 1917, and president two years later. In 1929 he relinquished the presidency to Mr. G. H. Houston and was elected chairman of the board.

During his fifty-seven years' association with the Baldwin works, Vauclain was responsible for many technical developments in the design and construction of locomotives. His best-known contribution was probably the four-cylinder compound locomotive which was first tested in 1891. Other developments for which he was largely responsible were the first "decapod" heavy goods engine, supplied in 1886 to the Dom Pedro II railroad of Brazil, the first "wagon-top" boiler, for the Denver and Rio Grande railroad, and the first "Mikado" locomotive supplied to the Japanese railways in 1897.

Vauclain's great abilities were not confined solely to the design of locomotives; he also introduced new methods connected with their construction and their sale. Shortly after becoming general superintendent of the Baldwin works he introduced the hydraulic forge for the production of driving wheel centres. A few years later he decided to reduce the idle time of the expansion machine tool in the company's shops and introduced the then novel principle of double shift working. He had ideas too for the individual motor driving of machine tools much in advance of the age, to such an extent, in fact, as to call forth the ridicule of his friend George Westinghouse. His abilities as a salesman were noticeable on many occasions, one of the most striking being that on which he completed a transaction with the Roumanian Government under which he sold it fifteen million dollars' worth of locomotives and machinery, the payment being made in sixty monthly instalments in cash or oil. The oil which was received as a result of this bargain was, it is said, sold by Vauclain to the British Government at a handsome profit.

In addition to his close association with the Baldwin works, Mr. Vauclain at the time of his death was a member of the boards of a number of banks and insurance companies, and a director of seven engineering and allied works, subsidiaries of the Baldwin Company. He also was a member of the boards of the Westinghouse Electric and Manufacturing Company and the Westinghouse Electric International Company.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

AUTOMATIC TRAIN CONTROL

SIR,—Our attention has been drawn to the letter from Mr. E. B. Parker which appeared in your issue of February 23rd, in which he refers to the SYX system of Automatic Train Control.

This apparatus was designed by the late Mr. E. S. Tiddeman, for many years chief draughtsman at the Stratford Works of the G.E.R., and the manufacturing rights were held by ourselves. It was in use for some time experimentally between Epping and Ongar, and also at some signals in the neighbourhood of Leyton, and on the Palace Gates branch line. High speed trials were also made on the Brentwood Bank.

The mechanism worked perfectly, and we have no doubt that had the G.E.R. remained a separate undertaking it would in all probability have been gradually adopted.

As your correspondent says, both distant and stop signals were successfully catered for, and in addition we would like to point out that a locomotive could back past the stop signal at danger, in the wrong direction, without any effect being produced.

We have always felt that this apparatus did not receive the credit it deserved when the Automatic Train Control Committee were conducting their enquiries.

F. J. SYKES,
Managing Director
(W. R. Sykes Interlocking Signal Co,, Ltd.).
26, Voltaire Road, Clapham, London, S.W.4.

COLONEL CROMPTON

SIR,—I take my courage in both hands to point out a slight error in the obituary article on Colonel Crompton!

The R.A.C.'S first show was not in 1903, but 1899. It was held on a "tented field" in the Old Deer Park at Richmond, and hill-climbing trials took place on Petersham Hill. I was an absorbed visitor and spectator—had contemplated entering my De Dion tricycle for the latter, even. A Barriere tricycle did best time—13 m.p.h. I think!

The R.A.C. 1903 activities were chiefly concerned with the Gordon-Bennett Race in Ireland, won by Jenatzy on a Mercedes. Edge was the only English finisher, on a Napier—and *he* was disqualified.

EDWARD H. LIVESAY.

(An illustrated account of the Automobile Club's show and trials appeared in THE ENGINEER of June 23rd, 1899. Our statement was taken from Colonel Crompton's "Reminiscences."—Ed.).

29, Fairfield Road, Croydon,
February 25th, 1940.

LIGHT-WEIGHT STEAM PLANT

SIR,—Your correspondent (February 16th) on the subject of "Light Weight Steam Plant" expresses a view held by many engineers with experience in both the light and heavy industries.

A fundamental equation which determines the cost in heavy industry is:—

Gross cost $= W(P+C) +$ on costs.
where W = Weight in tons.
P = Price of materials per ton.
C = Cost of production per ton.

In this equation only the "Weight" factor is under the control of the designer.

In all mobile power units the weight is an important factor, whereas in a stationary power unit, excepting that part of the plant which is mobile, the weight factor is often neglected.

Your correspondent mentions a weight of 1 lb. per B.H.P. for aero engines, 10 lb. per B.H.P. for Diesel engines, and 40 lb. per B.H.P. for a particular steam plant, but 2 lb. per B.H.P. is a more reasonable figure for commercial aircraft, and Diesel plant often is about 13 lb. per B.H.P. An investigation shows that turbine plant for power stations of the order of 50,000 kW. has a power to weight ratio of approximately 15 lb. per B.H.P. (inclusive of turbine, condenser, feed heaters, pumps, pipework, and valves), and of this the turbine accounts for 6 lb. per B.H.P., but this figure could be reduced by an application of light industry technique.

In comparing oil and steam plant, the oil refining plant should be considered in lieu of boilers. Many other questions arise in drawing up a true balance sheet, *i.e.*, useful life, capital cost, thermal efficiency, maintenance, continuity of service, fuel costs, &c.

A contribution to lightness could be made by the users of plant allowing the manufacturer more freedom in design and by insisting that weights are included in specifications.

JOHN W. HILL, A.M. Inst. M.E.
Newcastle-on-Tyne.
February 29th, 1940.

Sixty Years Ago

THE ST. GOTHARD TUNNEL

AT 11.15 on the morning of Sunday, February 29th 1880, the two headings of the St. Gothard tunnel established connection with one another. For the second time the Alps had been pierced. The Mont Cenis tunnel uniting the French and Italian railway systems had been begun in August, 1857, the advanced headings had met on Christmas day, 1870, and the railway had been opened in September, 1871. That tunnel was 7·57 miles in length. Scarcely had it been completed before the St. Gothard Railway Company was formed to drive a longer tunnel, 9·25 miles, for the purpose of connecting the railways of Germany and Italy without passing through French territory. On August 7th, 1872, a contract for the driving of the new tunnel was signed with Mons. Louis Favre of Geneva, the contract price, including all the works and the lining of the tunnel with masonry, being about two million pounds. Mons. Favre undertook to complete the work in eight years with a penalty if he failed to do so of £200 per day for the first six months, and £400 per day thereafter. In addition he undertook to forfeit a sum of £320,000 which he had deposited as caution money if the tunnel were not completed by the end of the ninth year. Numerous difficulties arose, and it was not until the middle of November, 1872, that work could be begun. Under Mons. Favre's energetic direction, construction was pushed forward at the greatest speed possible with the equipment then available. At first rock drills supplied by steam-driven air compressors were used. Later the compressors were driven by hydraulic turbines operated at one end by the waters of the River Reiss, and at the other end by those of the River Tremola. Soon it was found that the Tremola was an insufficient source of power, but Mons. Favre, nothing daunted, constructed an aqueduct 3000 m. long, and brought a reinforcing supply from the River Tessin. The compressors also supplied power for the locomotives used for hauling the debris out of the headings and air for ventilating purposes. Other difficulties arose. A bed of schist was pierced which discharged torrents of water into the workings. Then a stratum of "plastic material" was encountered which in effect transmitted a semi-fluid pressure from the superincumbent strata on to the centring and on occasion crushed the heavy granite voussoirs of the tunnel lining. More than once financial difficulties arose and threatened to add the tunnel to the list of unfinished projects known as "follies." Favre's zeal and determination, however, were not to be withstood by any difficulties, natural or human. He persisted until success was in sight, and then one day, in July, 1879, while inspecting the tunnel, he suddenly collapsed and died—one more death added to the total of between 60 and 70 which the tunnel had caused. He was only fifty-three when he died.

MINISTRY OF SUPPLY AREA ORGANISATION.—The Minister of Supply has inaugurated the Manchester Area Advisory Committee. The committee will advise the North-Western Area Board which has already been set up and consists of representatives of the Admiralty, Air Ministry, Ministry of Labour and National Service, and the Ministry of Supply. The secretary to the board, Mr. C. T. Dean, Ministry of Supply, Piccadilly House, Piccadilly, Manchester, will be pleased to place before the Board any propositions that a manufacturer or group of manufacturers may wish to make. Any joint body, federation, or chamber may also approach the board, provided the group or body is itself strictly a non-profit organisation.

An Oil Engine Research Laboratory

IN the course of a recent visit we paid to the Kadenacy department of the Armstrong Whitworth Securities Company, Ltd., at Buckingham Avenue, the Trading Estate, Slough, we had an opportunity of inspecting the special research laboratories which have been established and equipped by the firm for the further development of the original work of M. Michel Kadenacy on the exhausting and recharging processes of internal combustion engines, particularly those operating on the two-stroke principle.

At the last annual meeting of the company, the chairman, Sir Charles Bruce-Gardner, announced that the firm had recently completed a long-term programme of research and development work, covering the commercial application of the Kadenacy process to all types of internal combustion engines, including those for stationary, rail, and marine work, and that further development was proceeding on road and air transport engines. It may be recorded that the Armstrong Whitworth Securities Company, Ltd., of Thames House Millbank, London, S.W.1, and Slough, holds the exclusive right to grant licences under the Kadenacy patents to all countries with the exception of France. It is not, we understand, the intention of the company to engage in the manufacture of engines, and the function of the laboratories we are about to describe is to develop further applications of the Kadenacy system to different types of oil engines, and to provide an advisory and consultative service for the firm's licencees.

The laboratories which we illustrate on page 232 comprise two large bays on the Trading Estate, complete with drawing and administrative offices and well equipped engine test and physical laboratories. There is also an engineering workshop, in which machining operations connected with the construction or modification of engines are carried out, and a demonstration room in which representative types of Armstrong-Kadenacy engines have been installed, coupled to brakes and equipped ready for running under test conditions. This demonstration room also contains special apparatus designed to demonstrate the physical characteristics of the Kadenacy process.

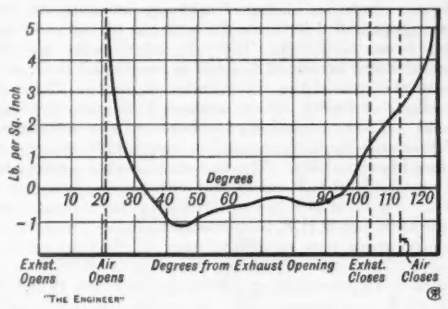
THE KADENACY PRINCIPLE

The contribution which M. Kadenacy has made to oil engine design is based on the phenomenon that immediately on opening rapidly the exhaust ports of a two-stroke engine, at the end of the expansion stroke, there is within the first interval of a few thousandths of a second an urge or impulse in the body of gases to escape as a whole very rapidly from the cylinder. By providing for the gases to escape in this manner and utilising the consequent suction effect, by suitable timing of the opening of the air admission valve or port, the new air charge is made to enter the cylinder immediately behind the escaping body of gases. The work of the inventor is distinguished from that of other investigators of exhaust effects in that while they have generally considered the problems connected with a more or less steady flow through exhaust pipes, over a series of cycles, he has examined the interdependence of the inlet and exhaust processes during a single cycle. He found that a definite explosive or ballistic effect can be caused to occur which is dependent upon the area-time factor of exhaust and which, if properly controlled and utilised, enables the cylinder to be completely charged with fresh air, the charging volume reaching up to one and a half times the cylinder volume. A further extension of his work has shown that it is possible, with suitable designs of inlet and exhaust arrangements, so to utilise the momentum of the exhaust gases leaving the cylinder that the period of time during which the depression or vacuum prevails in the cylinder is prolonged. By such means it becomes possible to extend the range of conditions under which advantageous charging can take place. This effect, it is pointed out, does not originate within the exhaust pipe, but the pipe is utilised to control the gases after they leave the engine cylinder. In practice the dimensions of an exhaust pipe, used with an engine operating on the Kadenacy principle, are comparable to those which would be used with a similar four-stroke engine. Actually, we saw Armstrong-Kadenacy engines running equally well with and without exhaust pipes, the basic principle of operation being undisturbed. This principle of the entry of the air charge being secured by the action of the mass of exhaust gas as it leaves the engine cylinder can be studied from the accompanying curve, which records the pressure readings taken from an Armstrong-Kadenacy engine working on the two-stroke cycle, during the period that the exhaust and air inlet are open. It will be seen that the pressure has fallen to 5 lb. per square inch at the moment the air admission begins, when the air flows into the cylinder directly from the atmosphere. Subsequently the pressure falls very little below atmospheric and it rises above that pressure as the air admission ceases. Although at the moment of opening the air inlet the pressure in the engine cylinder is above that of the atmosphere, no expansion of the gases out of the inlet take place, as the whole mass of exhaust gas has already taken its unidirectional motion out through the exhaust orifice.

As already mentioned, a further feature of the Kadenacy principle is the control of the motion of the exhaust gases after they have left the cylinder, which is accomplished by so arranging the exhaust system that the resistance offered to the outgoing mass of burnt gases is reduced to a minimum, and the mass of gas is kept moving in an outward direction a sufficiently long time, in order to enable the cylinder to be recharged with incoming air.

Important results, it is claimed, follow from the successful application of these principles. The weight of pure air entering the engine cylinder is increased, and more fuel can be burnt with higher mean effective pressures, there is also marked internal cooling, valves, pistons, and ports are not subjected to the higher temperature stresses normally associated with high outputs, and less heat is carried away in the jacket cooling water.

The successful operation of the engine with natural aspiration to which we have already referred does not preclude the addition of a blower, which may be utilised either for stabilisation or for supercharging the engine. In the case of a Kadenacy engine, however, the power required to drive the blower, we are assured, is less than that required for an engine which does not possess the natural aspiration or suction effect

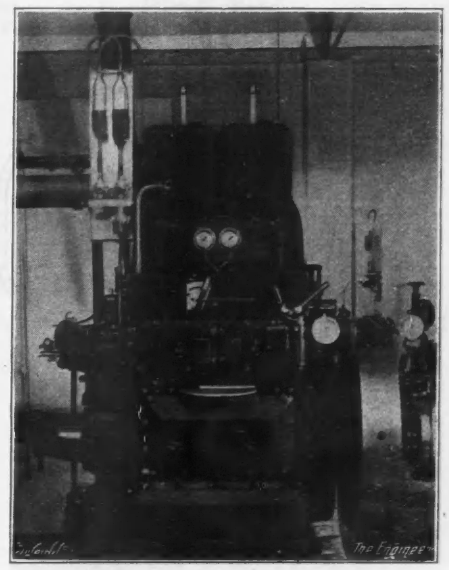


PRESSURE-TIME CURVE

associated with the Kadenacy process. These advantages were illustrated by the representative types of Armstrong-Kadenacy engines which were run for our inspection during our visit to the laboratory.

TWO-CYLINDER 125 B.H.P. PETTER SUPERSCAVENGE ENGINE

This engine is in its general design and construction similar to the series described in our issue of July 1st, 1938, in which results of a test made on a four-cylinder unit by Professor Hawkes were given. The engine we illustrate above was supplied by Petters, Ltd., and built in accordance with the Kadenacy patents, under licence from the Armstrong Whitworth Securities Company, Ltd. It was sent to Slough, and during the past few months has been the subject of experiment and improvements carried out in the laboratories. Although as originally designed it utilised the Kadenacy principle and the performance results both as regards fuel consumption and output were of a high order, it was found possible to improve further the correlation between the exhaust and air admission process, without having to modify seriously the design of the engine. In its new form the engine was recently tested by Professor S. J. Davies. The engine has two cylinders with a bore of 8½in., or 215·9 mm., and a stroke of 13in., or 330·2 mm. corresponding to a total swept volume of 24·1 litres. The rated output is 125 B.H.P. at 500 r.p.m. corresponding to a brake mean effective pressure of 67·1 lb. per square inch. The engine, we may recall, has air admission ports controlled by the piston, and two exhaust valves in the cylinder head, giving a one-direction flow of gases through the cylinder. It is equipped with a rotary type Zoller blower. The combustion chamber is of the open type with one centrally placed fuel-injection nozzle of the C.A.V.-Bosch pattern. The series of tests which were run at 500 r.p.m. constant speed and increasing load showed striking improvements in performance, compared with the earlier tests made by Professor C. J. Hawkes on a four-cylinder unit of this type, already referred to. The curves show that for an exhaust temperature of 690 deg. Fah., the brake effective pressure was raised from 80 lb. to 114 lb. per square inch, representing an increase of 42·5 per cent., while the moderate pressure and heat loading is indicated by the fact that at a brake mean effective pressure of 126 lb. per square inch the maximum pressure was of the moderate order of 935 lb. per square inch and the temperature 758 deg. Fah. Another noteworthy feature of the new performance was the wide range of output over which the specific fuel consumption was very low. Thus from 94 B.H.P. to 230 B.H.P., representing a range of brake mean effective pressures from 50 to 123 lb. per square inch, the specific fuel oil consumption was under 0·4 lb. per brake horse power hour. Over the range of 75 to 107 lb. per square inch B.M.E.P. the specific consumption was slightly less than the lowest consumption recorded by Professor Hawkes when testing the four-cylinder engine. The state of the exhaust was reported to be very good throughout the trials and the limit of satisfactory exhaust was shown to lie above the value of 120 lb. per square inch B.M.E.P. For these trials a



CONVERTED "SUPERSCAVENGE" ENGINE

pool gas oil of 0·847 specific gravity at 60 deg. Fah. was used, having a gross calorific value of 19,634 B.Th.U. per lb.

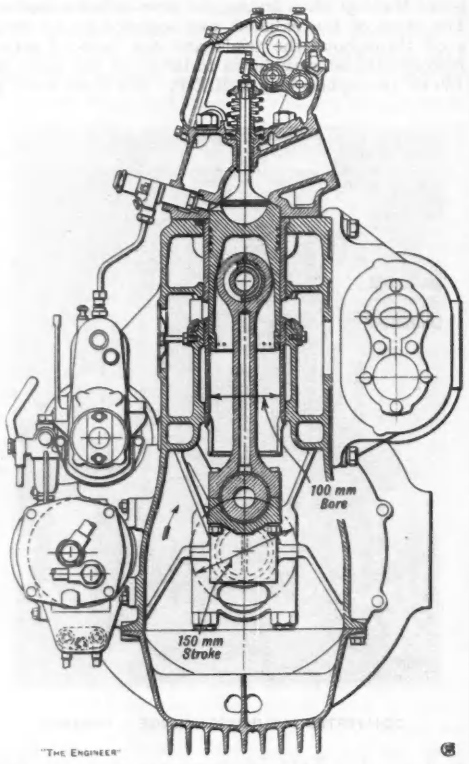
OPPOSED-PISTON JUNKERS TYPE ENGINE

Another example of an engine to which Kadenacy principles have been applied is the single cylinder Junkers type opposed-piston engine shown in our laboratory photographs. This was chosen as representing a high-rated two-stroke unit. It has a cylinder bore of 65 mm., or 2·56in., with a combined stroke of 210 mm. or 8·27in., the stroke of the upper piston controlling the operation of the air ports being 90 mm., or 3·54in., and that of the lower piston controlling the exhaust port 120 mm., or 4·72in. As originally designed the engine had a rectangular piston attached to the upper piston, which served as a scavenge blower and delivered air to the cylinder at a pressure of about 3 lb. per square inch. The Kadenacy system was applied to this engine by changing completely the characteristics of the air and exhaust passages and the exhaust pipe. The scavenge pump was rendered inoperative and the engine operated with natural aspiration. The original engine had a power range of 6·7 B.H.P. at 800 r.p.m., to 10·85 B.H.P. at 1200 r.p.m. with brake mean effective pressures of 78 lb. and 84 lb. per square inch respectively. When converted to the Kadenacy system and run under conditions of maximum rating, the power range was increased, the outputs of 8·6 B.H.P. at 800 r.p.m., and 24·9 B.H.P. at 1700 r.p.m., being recorded with brake mean effective pressures of 100 lb. and 136 lb. per square inch, respectively. It will be noted that the power output was increased by 130 per cent., without having to make any alterations either to the combustion chamber or the fuel injection equipment of the engine. The fuel consumption was reduced from 0·46 to 0·36 lb. per B.H.P. hour, while the maximum cylinder pressures were sensibly lowered. These results are well in advance of those hitherto obtained with two-stroke engines of this power, and clearly point to the benefits of the Kadenacy system.

SIX-CYLINDER ARMSTRONG-KADENACY 120 B.H.P. ENGINE

This particular unit, views of which will be seen on page 232 and in the sectional view reproduced herewith, represents an entirely new design of Armstrong-Kadenacy engine for stationary, marine, or rail transport. It has six cylinders each with a bore of 100 mm. and a stroke of 150 mm., giving a total capacity of 7 litres. The combustion chamber is of the Armstrong-Whitworth open type, and the fuel valve is of the C.A.V.-Bosch horizontal single-hole pattern. As will be seen from our engraving, a blower of the Marshall-Roots type is fitted and is utilised for stabilising purposes. The air enters through ports in the cylinder walls, which have tangentially arranged deflecting surfaces, imparting to the entering air a high degree of swirl. It is found that when

operating with natural aspiration the engine draws more than one cylinder volume of fresh air into the cylinder. With the blower in action, about two cylinder volumes per cycle are passed, the pressure between the blower and the cylinder only amounting to about 2 lb. per square inch. The maximum loads are obtained with a clear exhaust, which we observed. Under full load rating a power range of 56 B.H.P. at 560 r.p.m. up to 125 at 1200 r.p.m. was obtained with a brake mean effective pressure ranging from



SECTION THROUGH ARMSTRONG-KADENACY ENGINE

90 to 100 lb. per square inch. The fuel consumption curve has a flat characteristic at these B.M.E.P. values and is of the order of 0·417 lb. per B.H.P. hour. The exhaust temperature has a range from 300 to 390 deg. Cent.

Burmeister and Wain Auxiliary 120 B.H.P. Engine

This engine, which has been modified to conform to the requirements of the Kadenacy system, is a twin-cylinder two-stroke engine with a designed output of 120 B.H.P. at 400 r.p.m. It has a cylinder bore of 220 mm. or 8·66in., and a stroke of 370 mm. or 14·57in., the full power rating corresponding to a B.M.E.P. of 69·5 lb. per square inch. The engine is fitted with a Roots type blower which is chain driven from the crankshaft, and the injection of fuel is carried out by B. and W. type fuel pumps, one to each cylinder. The injectors are of the multi-hole pressure lift type, the quantity of fuel delivered being regulated by a centrifugal governor. The engine has been converted by the reconstruction of the cylinder, cylinder head, valve gear, and exhaust branches in such a way that the essential features of the air inlet and the exhaust systems have as far as possible been made to accord with the Kadenacy principle. No other changes were made, and the fuel injection system and the air charging blower remain unaltered. Careful tests were made before and after the modifications in design were carried out, and the principal results obtained may be stated as follows. The converted engine now carries the full rated load of 120 B.H.P. with an exhaust temperature of 265 deg. Cent., instead of 301 deg. Cent. in the original engine. At an output of 143 B.H.P. the converted engine has only the same exhaust temperature as that of the original engine when delivering an output of 120 B.H.P., while an exhaust temperature the same as that of the original engine operating at 134 B.H.P. permits of an output with the converted engine of 158 B.H.P., representing an increase up to 32 per cent. overload. The fuel consumption has been improved, and at full load it is 7 per cent. less than that of the original engine. The charging pressure of the converted engine is 17 per cent. lower at the full rated output than that of the original engine, and 19 per cent. lower at the overload rating of 134 B.H.P. In the case of the converted engine the charging pressure falls as the load increases, whereas it rises in the case of the original engine. The amount of heat rejected to the cooling water and lost in the exhaust gases is considerably reduced in the converted engine, as compared with the original engine, and these factors have allowed the permissible rated output of the engine to be increased materially.

In carrying out these tests an opportunity was taken to make experiments with the length of exhaust pipe. The main tests were carried out with an exhaust pipe and silencer practically identical with those used in the original tests of the unaltered engine in the engine maker's works. In that test there was a 10in. diameter tail pipe, approximately 25ft. in length beyond the silencer. On the converted engine a series of trials was run under full load conditions with the engine running at a speed of 400 r.p.m. and these special tests were made with thirteen different lengths of tail pipe, varying from nothing up to 150ft. The results show that throughout these tests the performance of the engine was not materially affected. The fuel consumption varied less than 0·25 lb. per B.H.P. hour, and the exhaust temperature only increased by 6 deg. Cent., while the pressure of the charging air only varied by 0·1 lb. per square inch between the minimum and the maximum value. These results show that in this case the influence of the exhaust pipe is rendered negligible. The diameter of the exhaust pipe can moreover be reduced, and it was found that using a tailpipe of 30 m. in length, an 8in. diameter pipe was needed for the original engine, whereas with the converted engine a pipe of 5in. bore sufficed. Another fact noted from the tests was the way in which the charging pressure of the engine fell off with an increase of the brake mean effective pressure. This reduced charging pressure, it is held, is explained by the fact that in the Kadenacy system the greater the energy in the exhaust, the greater will be the suction effect, tending to draw air into the cylinder, and thereby reducing correspondingly the resistance to the delivery of the air from the blower.

Single-Cylinder Armstrong-Kadenacy 5 B.H.P. Engine

An interesting application of the Kadenacy system to a small engine is that of the single cylinder unit with a bore of 2⅞in. and a stroke of 4½in. with a capacity of 438 cc., and a designed output of 5 B.H.P. when running at 1000 r.p.m. It operates without a blower, but by using Kadenacy designs an air throughput of 1·3 times the volume of the cylinder has been achieved. The air inlet ports in the cylinder are arranged to give a tangential flow, and as in the case of the six-cylinder engine we illustrate a single exhaust valve arranged in the cylinder head. The combustion chamber is of the Armstrong Whitworth open type, and a single-hole sprayer is placed horizontally. The test results show a comparatively flat B.M.E.P. curve, and with a brake mean effective pressure of 75 lb. per square inch, a fuel consumption of 0·41 lb. per B.H.P. hour was recorded. The exhaust temperature was moderate over a wide range, and varied between 220 deg. Cent. at a B.M.E.P. of 45 lb. per square inch and 260 deg. Cent. at a B.M.E.P. of 85 lb. per square inch. The engine is particularly neat in its design, and forms a new departure in two-stroke practice as applied to small engines.

Conclusion

From the description we give of the engines in the laboratory, it will be evident that noteworthy improvements have been recorded with standard engines of different sizes and types. It is pointed out, however, that in some of these cases the full benefits of Kadenacy principles could not be obtained owing to the limitations which were presented in modifying the engine designs. In actual practice it was only possible to make a somewhat restricted and practical compromise and some types and designs have permitted a more complete adaptation than was possible with others. It is claimed that given greater freedom in engine design, especially with regard to the exhausting and recharging functions, some still further improvements in engine performance may be looked for.

Motor Transport*

By E. C. OTTAWAY, A.M. Inst. M.E.†

The Double-Deck Omnibus.—A double-deck omnibus representative of the latest practice in Great Britain has the engine in the front and a large single entrance with a low platform situated at the rear. The persistence of the rear entrance, in spite of many attempts to popularise alternative arrangements, is almost universal. A few front-entrance double-deck buses are used in certain localities, and under special circumstances. It is generally believed, however, that the rear entrance permits quicker loading, enables the conductor to control the vehicle more effectively, and that it gives greater security from boarding and alighting accidents. The limited overall length precludes the use of more than one combined entrance and exit, and under these circumstances the use of doors has been found to increase loading times. It is also the convenient practice of intending passengers to board or alight from the vehicle when travelling slowly in congested traffic, or when stopped by signal lights.

Much thought has been given to the possibility of locating the engine beneath the floor, or at the rear, with a view to increasing the space available for passengers. It is clear, however, that the rear entrance, in combination with the low floor height necessary to give adequate headroom and a low centre of gravity, favour the front position for the engine. An alternative arrangement was exemplified in the "Q" type vehicle, with side engine, produced by the Associated Equipment Company in 1933; the arrangement did not find favour and was not perpetuated.

There are other reasons for the retention of the orthodox position of the engine in front. The front axle may be placed well forward, with consequent reduced loading, better steering, and road holding qualities. Furthermore, this arrangement places the objectionable front wheel arches outside the passenger space, thus obviating the use of inward facing seats, and facilitating a symmetrical interior layout.

The double-deck bus is limited to 26ft. overall length and 10½ tons (23,520 lb.) maximum laden weight if of the two-axle type, or 30ft. and 12½ tons (28,000 lb.) if of the three-axle type. In consequence of this regulation, considerable interest was taken in the six-wheel type from 1926 to 1933, and many vehicles were built with the object of taking advantage of the increased weight and size permitted. The then London General Omnibus Company built some thirteen hundred buses of this type, the majority of which are still operating. A close study of the relative merits of the type under large-scale operating conditions was therefore possible. It became apparent that for urban services, with the variable fare system, it was in many cases difficult for the conductor to deal with seating capacities in excess of fifty-six. Statistics were obtained of the relative operating costs of four- and six-wheel vehicles, which indicated an increase of 11 per cent. in operating cost and some 13 per cent. in respect of capital charges and depreciation, for the six-wheel bus. The only advantage which justifiably could be claimed for the type was the superior riding given by the twin-axle construction. This advantage has been subsequently negatived, to some extent, by the introduction of low-pressure tyres on the two-axle vehicle. It was concluded therefore, on economic grounds, that the six-wheel type could only be justified when traffic conditions and the fare system in use permitted capacities in excess of sixty-five.

TABLE I.—*Distribution of Weight of Standard Double-Deck Omnibus*

	lb.
Steering	105
Paint	229
Indicators	234
Electrical	412
Fuel, lubricating oil, and water	420
Windows, fixed and drop	486
Springs	750
Chassis frame	952
Seats	977
Wheels and tyres	1130
Engine, gearbox, and dynamo	2072
Front and rear axles	2838
Body shell	4895
Passengers, driver and conductor	8120

The relatively low maximum weight imposed by legislation introduces a particularly difficult problem in the case of double-deck vehicles. The distribution of weight on a typical vehicle of this type is shown in Table I, which indicates the manner in which the total weight of 23,520 lb. is allocated. It will be seen that 8120 lb. is accounted for by the passengers, driver, and conductor, some 420 lb. for fuel, oil, and water, and 6821 lb. for body and fittings, leaving a mere 8159 lb. for the mechanical parts of the vehicle, including wheels, tyres, engine, and frame.

Single-Deck Omnibuses and Coaches.—Until recent years, the design of this type of vehicle was not considered independently of the double-deck bus. The same type of chassis was used for both, and low overall height was considered æsthetically desirable, even at the cost of headroom and the passengers' view. A high floor, however, reduces the protrusion of wheel arches into the passenger space, and gives a better view. Moreover, low traffic density and long fare stages do not necessitate extremely rapid loading and hence any objection to a double-step entrance is eliminated.

The adoption of the high floor has opened the way for consideration of alternative chassis arrangements, with a view to the more efficient utilisation of the space available and the provision of a greater seating capacity. For the time being, however, the orthodox position of the engine retains its popularity. Two practical alternatives are the rear engine design, which has achieved considerable popularity in America, and the under-floor arrangement, which has also been adopted in a considerable number of vehicles.

The location of the engine and gearbox transversely at the rear of the vehicle, with a skew drive to the axle, is practicable where the permitted overall width is 8ft., but is far more difficult under the restriction to 7ft. 6in. ruling in Great Britain at the present time. Under the most favourable circumstances the dimensions of the clutch housing and gearbox must be reduced to a minimum, and little scope is allowed for epicyclic gear-boxes, torque converters, or other automatic devices, rendered increasingly necessary by the remoteness of the driver from the engine and transmission. The transmission unit is necessarily more complex and includes an additional pair of gears. Some difficulty has also been

* Excerpts from a paper to have been presented at the 1939 American Meeting of the Institution of Mechanical Engineers.

† Technical Officer (Buses and Coaches), London Passenger Transport Board.

experienced in providing satisfactory engine cooling under adverse conditions. Advantages claimed for the transverse engine include a reduction of noise within the vehicle, and improved accessibility of the engine and gearbox unit. It is also probable that the effects of engine vibration may be more easily dealt with, since the reaction to such vibrations is normal to the longitudinal axis of the vehicle. The weight distribution of the rear engine arrangement seems at first sight open to objection on the grounds that an unduly light front axle load will have a tendency to cause instability. Experience, however, has shown that, on the contrary, an improvement in stability is effected, together with a reduction in steering effort.

The alternative under-floor engine arrangement permits a completely clear floor space for passengers, and a very straightforward transmission layout, with ample scope for special forms of transmission. It also possesses an important advantage in that a front-end radiator may be used with grouped auxiliaries driven from the front end of the engine. A careful study of the maximum seating possibilities of the two types, having regard to British regulations, shows a slight superiority for the under-floor arrangement. The rear engine arrangement necessitates a deeper rear seat to accommodate the engine than is required for the passenger's comfort; moreover it eliminates the possibility of a rear emergency door, which must then be provided within the body side.

The arguments in favour of the rear engine design are stronger in the case of one-man operated vehicles of the 20-seat type. Such vehicles are often required to operate on routes traversing secondary roads where manœuvreability is of importance. In consequence, their wheelbase and overall length must be kept to a minimum. In this class of vehicle the entrance must necessarily be situated at the front under close control of the driver. The relatively short length precludes the use of a floor sufficiently high to accommodate an under-floor engine. The London Passenger Transport Board placed in service experimentally numbers of vehicles of both types, namely 34-seat coaches with under-floor engines for express work, and 20-seat one-man buses employing the rear engine arrangement, for use on "development" routes. The mechanical design of these vehicles is of some interest, and the lay-out of a rear axle drive of a rear engine bus is illustrated in Fig. 1.

The larger vehicle is equipped with a six-cylinder engine substantially similar to the orthodox vertical engine; standardisation of details is thus attained. All parts of the engine requiring adjustment can be brought to the outside, where they are accessible without the use of a pit. At the same time the crankshaft axis lies approximately along the centre line of the vehicle, providing a simple and symmetrical transmission arrangement on orthodox lines. The engine is mounted on rubber and the vehicles are particularly free from vibration. The radiator is situated at the front. The engine fan, in combination with the ventilating unit, dynamo, and compressor are driven by a straight cardan shaft from the front end of the crankshaft.

The smaller vehicle of the rear-engine type has the power unit arranged longitudinally at the rear. This arrangement was chosen because the small engine used (3¾in. bore × 5in. stroke) requires little more space than with the transverse arrangement, and the transmission problem was again simplified. The engine and transmission are arranged as a unit in such a manner that the engine, gearbox, or clutch, may be removed separately by withdrawing the internal primary shaft; alternatively, the complete power and transmission unit may be withdrawn from the chassis. Some difficulty was encountered in the early stages of design in providing sufficiently long side shafts to enable the maximum angularity to be kept within reasonable limits. This difficulty was overcome by passing the side shaft through the hub and mounting the universal joint within the dish of the outer wheel; this measure enabled the maximum angularity to be kept within about 6 deg.

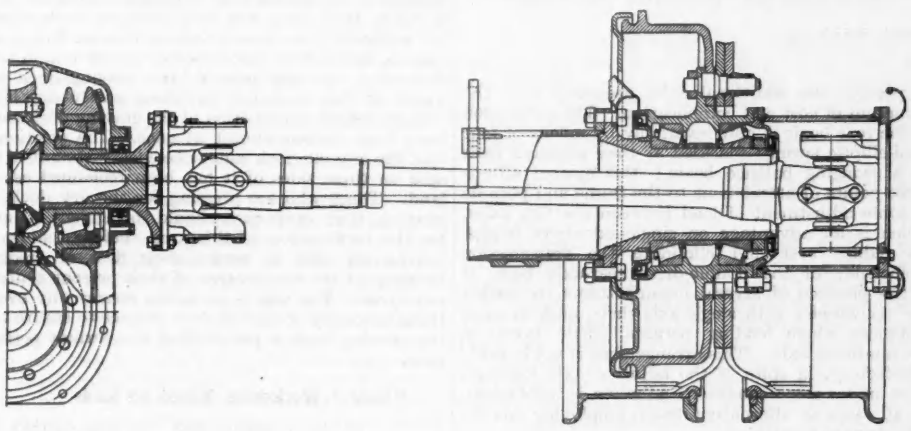


Fig. 1—*Mechanical Lay-Out of Rear Axle Drive of Rear Engine Omnibus*

The alternative positions of the engine outlined above simplify the provision of a full-fronted body, and thus contribute to an improvement in appearance which has generally been accepted. Experience in London, however, has revealed some important disadvantages in comparison with the half-cab arrangement which has hitherto been the accepted practice. The driver's view in bad weather is adversely affected by the increased distance of the major part of the windscreen glass from his eye. In addition, reflections from passing lights and from the interior of the vehicle are more difficult to deal with. Accident statistics have shown the importance of the driver's view. It is desirable that a small child standing immediately in front of the vehicle should be visible to the driver, and that blind spots be reduced to a minimum. With the full-fronted design the waist must be extremely low at the front to give the required view above the near-side windscreen glass.

To meet these objections, a compromise between the full front and half-cab design has been devised, and is embodied in the vehicles which have been described. This arrangement has been found extremely satisfactory in service and entails very little sacrifice of passenger space. The improvement of the driver's view is considerable even when compared with the half-cab arrangement, and by the provision of suitable blinds the driving cab can be completely darkened. During periods of fog, a serious difficulty in our large cities, the nearside window of the cab may be opened outwards and the roadside kerb may be easily seen a few inches in front of the near-side wheel.

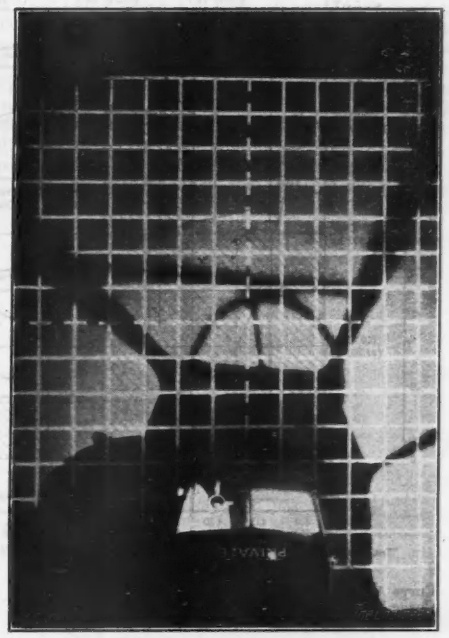
The subject of driver's view has received considerable attention of late. It was apparent, particularly in the case of the private car, that insufficient importance was being attached to this feature. In consequence, the Society of Motor Manufacturers and Traders has laid down certain minimum standards. In the case of public service vehicles and trucks, these standards are easily attained, and should in all cases be improved upon. An interesting comparison of the ground level visibility from vehicles may be made by photographic means, Figs. 2 and 3. The vehicle is placed in a darkened shop or garage, and a light is placed in the cab at the position of the driver's eye level; a photograph is then taken from above and gives an outline of the limits of floor visibility. This method may be rendered quantitative by marking the floor in rectangular spaces of equal size and carefully placing the vehicle in relation to the markings.

Chassisless Construction.—This form of construction, though generally used in America, has made little headway in Great Britain. Experimental vehicles have been produced and the subject is widely discussed. It is probable, however, that certain differences in the conditions prevailing in Great Britain will retard its progress.

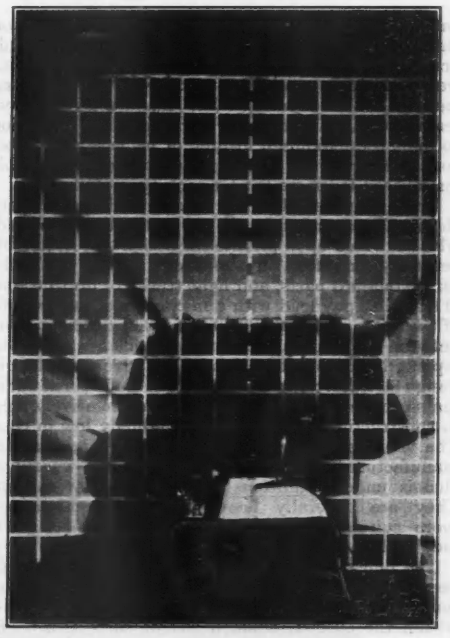
The manufacture of road transport vehicles in Great Britain is, in the main, sharply divided between body and chassis. It will be apparent therefore that the development of the chassisless form of construction will inevitably be hindered by administrative considerations.

The primary advantage claimed is presumably a reduction in weight. It will be seen, however, by reference to Table I, that the weight of the chassis frame of a typical double-deck bus amounts to approximately 952 lb. To this may be added 560 lb., representing the weight of the structural parts of the body floor frame, giving a total of 1512 lb., or roundly 6½ per cent. of the total laden weight. Were it possible to save half the weight of the body floor the total saving would be equivalent to approximately 1 per cent. of the laden weight, an amount for which the most ardent gambler would be prudent in the matter of risk. It is essential, when considering the merits of this form of construction, to ensure that a fair comparison of like with like be made. It is often the case that improvements in equipment resulting in weight reduction are made concurrently; or the stress factor may be of a different order.

From the standpoint of the large operator there are certain drawbacks. Periodic overhauling may be carried out more economically by separation of the body and chassis. The maintenance of large numbers of vehicles of a similar type can be most economically achieved by means of a floating supply of bodies and units such as engines, gearboxes, &c. This system is particularly applicable where large fleets are concentrated in a relatively small area, and in consequence it has been developed to a high degree by the Bus and Coach section of the London Passenger Transport Board. It has been found impracticable for the chassis and body to be dealt with concurrently, and, moreover, the time occupied in body repairs and repainting is necessarily longer than is required for the changing of units and adjustment of the chassis. By the provision of a floating supply of bodies the time during which the vehicle is withdrawn from service is reduced to that required for the chassis, and the complete overhaul may be accomplished in five days as compared with ten days normally occupied by the complete process.



Flat-engine coach



Double-deck omnibus

Figs. 2 and 3—*Photographic Method of Comparing Visibility Characteristics*

Goods Vehicles.—With a view to presenting a composite picture, the relationships between unladen weight and pay load of some seventy vehicles on the British market has been plotted in Fig. 4. It has, moreover, been possible to indicate on this diagram the arbitrary limits of taxation, speed, and maximum laden weight, together with the number of vehicles of each class in use. A study of this diagram will readily disclose certain fundamental considerations affecting the manufacture and operation of goods vehicles in Great Britain. It will be observed, primarily, that the vehicles in use below an unladen weight of 2½ tons (5600 lb.) greatly outnumber vehicles above this unladen weight, and this has led to the production of these lighter vehicles on a quantity basis. This, in turn, has influenced their design and general appearance.

At the same time the number of vehicles in use above this line of demarcation is not negligible. The fact that the line of demarcation between these two types occurs at the unladen weight limit permitting a speed of 30 m.p.h. has resulted in the two classes overlapping at this point. The manufacturers of the heavier chassis produce light vehicles with a view to carrying upwards of 6 tons pay load at a speed of 30 m.p.h., whilst the makers of the lighter type of chassis normally falling within the lower taxation rating claim high pay load capacities to meet this competition. The tendency of taxation on a basis of unladen weight, and speed rating, to encourage overloading is thus well illustrated, and the anomalous position has arisen that manufacturers are publishing data permitting pay loads of 5 tons (11,200 lb.) on chassis nominally rated at 3 tons (6720 lb.). This practice was fast becoming a menace in that claims were made for capacity far exceeding the designed loading of the chassis. The manufacturers have realised this, and are supporting impending legislation to limit the maximum loading of vehicles. It is becoming the practice to give the maximum permissible guaranteed laden weight for each type of chassis.

The lighter vehicles may be subdivided again into the small van of up to 1 ton (2240 lb.) pay load, which is based upon private car design and is, in fact, generally produced in the same factory with the same standard parts, and light trucks of up to 5 tons (11,200 lb.) pay load with a maximum chassis weight of the order of 35 cwt. (3920 lb.). The differentiation between light trucks and heavier vehicles, whilst overlapping in respect of load capacity, is very marked in design features. Light trucks are manufactured under mass-production conditions; they are relatively light in construction, and are correspondingly low in cost. The vehicles comprising the heavier goods class are manufactured by the makers of large passenger chassis under conditions of relatively low output. They are generally heavier in construction and more suitable for long-period maintenance, as is inevitable in view of their greater first cost.

The line plotted in Fig. 4 giving the capital cost per ton of pay load capacity, shows that the minimum cost is reached by those vehicles falling just within the 50 cwt. unladen weight class as a result of their artificially increased pay load. Were it not for this it is probable that the cheapest vehicle in relation to pay load would be the type of which the greatest number are built, namely the 30 cwt. to 40 cwt. unladen weight class.

The light vans are exclusively of the bonneted type, and disclose their origin by a general similarity of radiator and bonnet with their private car prototype. The light trucks are, in the majority, of the bonneted type, but forward control designs are available in the larger sizes. An analysis of a number of the more representative types shows that with the forward control 78 per cent. of the overall length is available as body space, whereas with the bonneted type only 63 per cent. is available.

In appearance the light trucks have developed an individuality like the private car, whose rapid changes of fashion they follow. Among the larger and heavier vehicles the appearance is more stable, showing a similarity with the large passenger vehicle prototype. The mechanical design of the lighter vans and trucks follows, in the main, usual lines. Petrol engines are generally fitted, and it may be observed that the number of oil engines in use below the 2½ tons (5600 lb.) unladen weight classification is almost negligible.

It will be seen from Fig. 4 that for the carriage of loads in excess of 150 cwt. (16,800 lb.) the law demands the use of three axles, and for loads in excess of 260 cwt. (29,120 lb.) a four-axle chassis is required, corresponding approximately to a gross weight of 4 tons (8960 lb.) per axle. The direct result of this legislation has been uniformity of tyre sizes and interchangeability of axles, the increased load capacity being obtained by a further interchangeable axle. The 36in. × 8in. tyre with a load capacity of approximately 2 tons (4480 lb.) per tyre is almost universal.

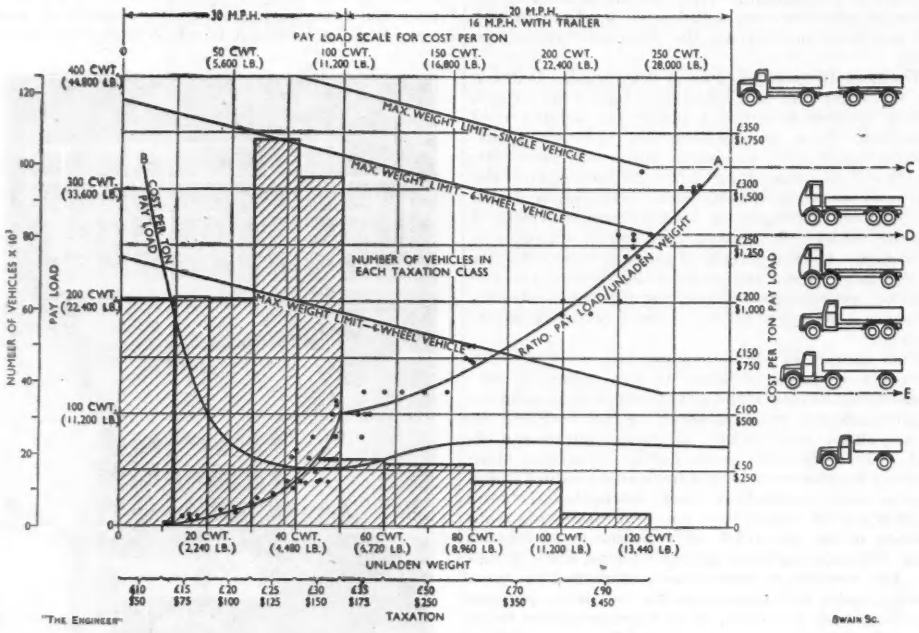
Much ingenuity has been displayed in attempts to provide the additional axles necessary with the minimum of cost and complication. The suspension of the rear bogie is now invariably by means of four semi-elliptic springs shackled at their adjacent ends to a swinging balance beam; this system affords three points of attachment to the frame and permits of some adjustment of load between the two axles, which is an advantage on single-axle-drive bogies. To reduce cost and eliminate the transmission inefficiency of the double-drive rear-axle bogie it is the practice of several manufacturers to market the six-wheeler with single-axle drive and, in some instances where loading permits, single tyres on the hindmost axle. This arrangement is not entirely satisfactory, in spite of the adjusted axle loadings, since under some conditions adhesion is insufficient. In all cases an alternative design employing double-axle drive is available.

With a view to obviating these difficulties certain manufacturers are employing twin steering front axles and a single rear axle. By this means the maximum weight is available for adhesion on the driving wheels and tyre scrub is eliminated. Moreover, by the use of twin tyres on the single axle, equal tyre loadings are obtained.

Trailers have not achieved the popularity in Great Britain that is observable on the Continent, largely because of the reduction in speed their use entails. In spite of this, the trailer finds favour for certain classes of work. Its advantages mainly lie in operation, and are most apparent where one towing vehicle can serve two or more trailers, and thus minimise idle loading time.

The subject of trailers would not be complete without some reference to the articulated five-wheel vehicle, or "mechanical horse." This arrangement, originally developed to meet the needs of the railway companies in displacing the horse for short hauls, has achieved considerable popularity. The tractor has an automatic coupling and a single forward steering wheel and can turn in little more than its own length. It is capable of a speed of 20 m.p.h., and in larger sizes will haul a 6-ton (13,440 lb.) pay load. This arrangement has a particular advantage for municipal transport in towns of medium size, where the capital expenditure involved in the provision of separate self-contained vehicles for each and every purpose would be prohibitive. One tractor of the mechanical horse type employed with a carrier unit for each purpose is a very satisfactory solution.

(To be continued)



Curve A—Ratio of pay load to unladen vehicle weight.
Curve B—Cost of vehicles per ton of pay load capacity.
Curve C—Maximum limit of pay load for a single vehicle.
Curve D—Maximum limit of pay load for six-wheel vehicles.
Curve E—Maximum limit of pay load for four-wheel vehicles.

Fig. 4—*Characteristics of Goods Vehicle Types*

South African Engineering Notes

(By our South African Correspondent)

Graving Dock Needed at Table Bay

Now that the Parliamentary session has begun—it was opened on Friday, January 19th—there is likely to be strong representation of Cape Town's need for a new graving dock. The subject is not new, but so far nothing has been done. Those more vitally concerned with this matter, however, have not abandoned their efforts, and at least one representative deputation will again take an early opportunity to impress upon the Government the imperative necessity for making immediate provision for this facility for shipping in the new Table Bay harbour. The war factor need not be used as the chief argument in justifying the claim for a modern graving dock, although it would be a great pity and certainly a loss of prestige if Cape Town were suddenly called upon as a result of war action to render assistance to, or repair, some valuable ship and was unable to do so. The important fact is that an up-to-date graving dock was included in the new Table Bay harbour scheme and was agreed to in principle by the Government. Unfortunately, it appears on the plan in the "future" section of the harbour scheme and not in the "immediate" which is due for completion in about eighteen months' time. It is now urged that the "future" need of two years ago has already become "immediate." There appear to be sound reasons for supporting this contention.

The plan shows the site of the graving dock on the Woodstock side of the new harbour. Before it can be constructed the area around it—now sea water—must be reclaimed. This reclamation is also in the "future" section of the harbour scheme and is not included in the present contract of the Dutch dredging contractors. This chopping up of the ultimate harbour scheme into two sections—"immediate" and "future"—has not worked well in practice. For example, the dredgers now deepening the new harbour area have found less sand and more rock than expected. All material recovered is used to reclaim the foreshore. Even a year ago it would have been economical for the dredgers, in view of the unexpected nature of the substance then being recovered from the new basin, to have dumped that substance in the area of water around the site of the graving dock. However, the contractors were not concerned with filling in that area, and they dumped it elsewhere. No authority has been given to reclaim this small section, but had the two sections of reclamation been dovetailed the area around the graving dock site would at this moment have been partly dry land, and the actual construction of the graving dock could have been started almost at once. The position is that the graving dock cannot be constructed until the area on three sides of it has been reclaimed as dry land. Those who are pressing for the dry dock are anxious that authority should be given at once for the reclamation of this area—before the Dutch contractors wish to return their fleet of dredgers overseas at the termination of their present contract next year. The war is an added reason why everything necessary should be done at once to ensure that the graving dock is provided at the earliest possible date.

"Iscor" Workshops Moved on Skids

A clever engineering feat was carried out at the South African Iron and Steel Corporation's works recently when the electrical workshops, a building 160ft. long by 50ft. wide, and weighing about 160 tons, were lifted bodily and moved 88ft. This operation is believed to be the first of such magnitude to be carried out in South Africa. It was made necessary because the electrical workshops stood directly in the way of important extensions required to the mechanical workshops. These extensions form part of a programme of expansion upon which the engineers have been engaged for some time. The electrical workshops consist of a structural steel frame building covered with a corrugated iron roof. Before the building could be shifted the steel framework had to be reinforced by stays consisting of 96 lb. railway rails and of wire rope tension stays. Special tackle had to be devised for the job. Moreover the "shift" had to be carried out without interfering in any way with the normal programme and electrical maintenance work. The building had first to be moved 30ft. to the north and then 8ft. to the west.

First of all the vertical columns were jacked up sufficiently to allow the builders to clear obstructions on the ground, and adjust the 96 lb. rails which were used as skids. The vertical columns were skilfully mounted on these rails and plenty of grease applied to facilitate the haul. All manner of pulling tackle had to be used and anchorages contrived against which the pulling could be done. The latter were obtained by sinking cocopans 6ft. into the ground. Eight hand winches were used for the actual hauling. As they were all of different sizes, considerable ingenuity had to be exercised to ensure a steady pull. The pull had to be uniform at all points to prevent distortion of the framework. The actual time taken to move the building northwards was

1 hour 5 mins., and the movement westwards occupied 45 mins. The entire job of planning, preparing the new site, and transferring the building took only ten days. The operations are fully described in the "Journal" of the Corporation.

It may be mentioned that for some time, and particularly since experiencing periodic waves of international tension, Iscor directors and executives have been giving special attention to the question of the local manufacture of spare parts for replacements and many items of plant and equipment which had previously been purchased overseas. Towards this end extensions to the foundry and the machine shops have been provided for and a large expenditure has been incurred in installing additional and up-to-date machine tools. These improvements involved the use of the boiler and erecting shop for other purposes and instead of building a new and enlarged boiler shop it was decided by arrangement with the other shareholders in the Pretoria Steel Construction Company (Pty.), Ltd., to purchase their holding in that company and to take over for use as a boiler and erecting shop, the properties, works, and plant of that company which are adjacent to the Iscor works. Approximately £200,000 has been spent or provided for over the last eighteen months to two years with the object of making the works more independent of overseas supplies and generally of safeguarding the industry against the possibility of the stoppage or restriction of overseas supplies. Since Iscor Works started up a sum of £438,461 in all has been provided out of revenue for additions and improvements to plant and properties, including amenities for the staff, of which £203,759 was set aside during the year ended June 30th, 1939. Of the £438,461 so set aside, £303,924 had been spent up to June 30th, 1939, adding considerably to the efficiency and the profit earning capacity of the plant.

Plant to Produce Steel and Ferro-Alloys

Dr. H. J. van der Bijl, Director of War Supplies, chairman of the Electricity Supply Commission, and chairman of the South African Iron and Steel Corporation, has just announced that the large works at Vereeniging will without doubt be launched when the international position warrants it. Dr. van der Bijl said that had it not been for the outbreak of war the scheme might already have been started. He was in England on business connected with the scheme when the war interrupted his plans. The scheme involves raising £5,000,000 capital to finance a huge new steel and ferro-alloy production plant to be established at Vereeniging under the control of the African Metals Corporation. This is a private company whose shareholders include mining houses and big steel concerns in England. It has been operating for two years at Newcastle, where it is making ferro-manganese and pig-iron. Its production at present is 4000 tons of pig-iron and 1700 tons of ferro-manganese a month. It supplies all the country's requirements of ferro-manganese, and has for the first time made South Africa independent of overseas supplies of that commodity. Dr. van der Bijl's aim is to make the steel industry absolutely independent for all raw materials. The industry requires not only coke, iron ore, and lime, but ferro-manganese, ferro-chrome, and ferro-tungsten. The object of the new company is to make these ferro-alloys and also to make more steel, but steel of a kind which cannot be made by Iscor at Pretoria. "What we do at the new works must rationalise with what is done at Iscor; the two projects must dovetail" said Dr. van der Bijl; he added that further expansion was contemplated at Iscor. A big new wire works was to be established with an initial production of about 35,000 tons a year, which was about 40 per cent. of the Union's requirements. At present, South Africa's supplies of wire were almost entirely imported.

Manufacture of Chlorine Gas

One of the first of the new industries to be established on the Rand in consequence of the war is the manufacture of chlorine gas. A big pulp and paper manufacturing concern has informed the Johannesburg City Council that it has decided to manufacture the gas if there is found to be sufficient demand, and it offered to supply the Council for its public health requirements at a cost considerably lower than the price of its last overseas contract. The city engineer has suggested, and the Public Health Committee has recommended, that the Council should accept the offer at the confidential price quoted on a three-year basis provided the quality of the product is up to previous standards. Chlorine is also used extensively on the Rand in purifying water and in bleaching processes. Supplies have hitherto come from overseas, but the effects of the war on communications and costs make it desirable to ensure a continuous supply from local sources.

New Railway Works

The provision of new and modern railway works in Pretoria, estimated to cost over £1,000,000, has been proceeding according to schedule. The construction of the marshalling yard and its service station, the locomotive depot, has advanced considerably during the past few months. The tracks have been laid, and at the locomotive depot nearly all the inspection pits have been built. Workmen are now erecting the steel frame for the sheds.

Port Elizabeth's Big Dam

The task of building Port Elizabeth's great dam has begun in earnest. This dam, which is being built across the Kromme River, seven miles from the city, will be South Africa's first multiple arch dam, and is designed to hold 7,823,000,000 gallons with provision for enlargement when necessary to 12,500,000,000 gallons capacity. It is expected that it will take two and a half years to complete. The single pipe line which is being laid concurrently with the raising of the wall will supply the city with 5,000,000 gallons a day.

Developing Union's Timber Industry

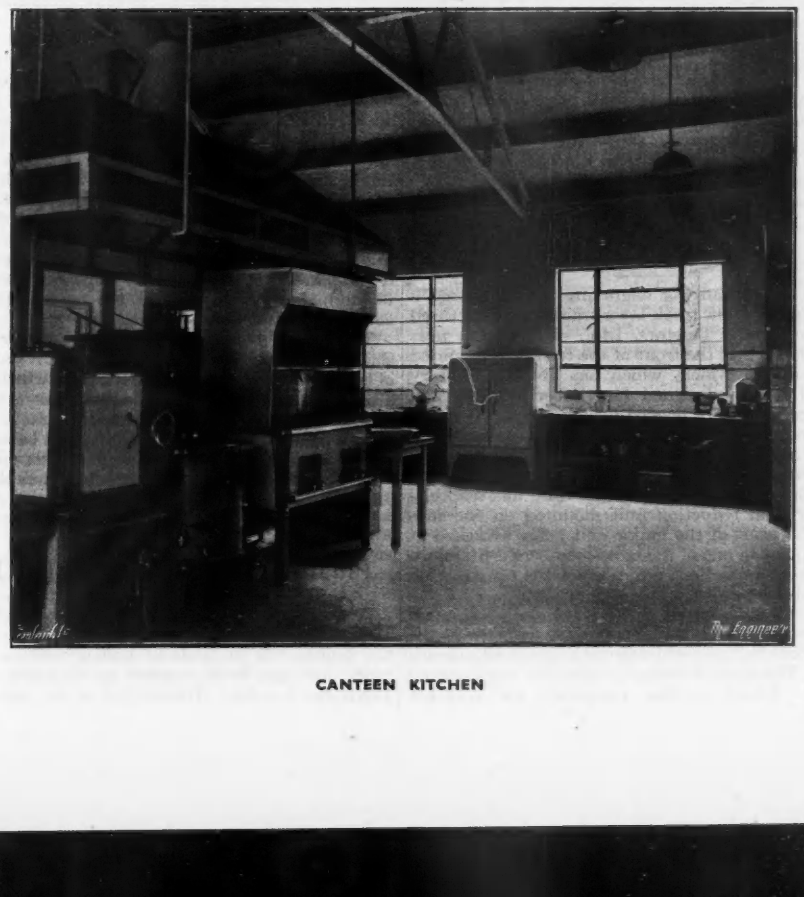
Mr. A. Jurriaanse, statistician in the Division of Forestry, has just published information showing the great development that has taken place in the Union's Coniferous timber industry. Although prospects are considerably improved, the Union is still dependent on overseas supply for the greater part of its timber requirements. He points out that timber from the Baltic can be practically ruled out for the present. This fact has thrown a big increase in the demand on the timber products of Canada and America from many other countries besides South Africa. This demand has already caused the f.o.b. prices from Canada to increase by 25 per cent. Mr. A. Jurriaanse comes to the conclusion that South Africa's imports of coniferous timber for fruit boxes, for industrial purposes, plywood, and pulpwood, &c., will become much restricted, and that the Union will be able to land possible imports only at high prices. About 6½ million cubic feet in the round of coniferous timber 5in. to 8in. in diameter, or after being sawn about 2 to 3 million cubic feet, could be supplied from the Government plantations. This total of sawn wood is still less than the annual imports before the war of boxes only, viz. about 4,000,000 cubic feet. The Union's contribution to its timber requirements is therefore still very small, and it is dependent on supplies from overseas for the greater part of its requirements.

Canteen Kitchen Equipment

THE new canteen kitchen of a large engineering firm has recently been completely fitted with gas heated cooking and other equipment by Radiation, Ltd. The equipment, which has been designed for the preparation of meals for 300 persons at one time, includes a double oven "Bordo" range; a two pan "Wardour" fish fryer; a two gallon "Lune" vegetable boiler; a vapour heated hot closet and serving counter; a steamer; and a "Savoy" griller on a stand.

In the accompanying engraving is shown one part of the kitchen, and in it may be seen the fish fryer, vegetable boiler, and the steamer, which are set back-to-back with the other equipment. The whole group is situated under a glass hood which collects steam and cooking fumes and discharges them through a central trunk to the outside of the building.

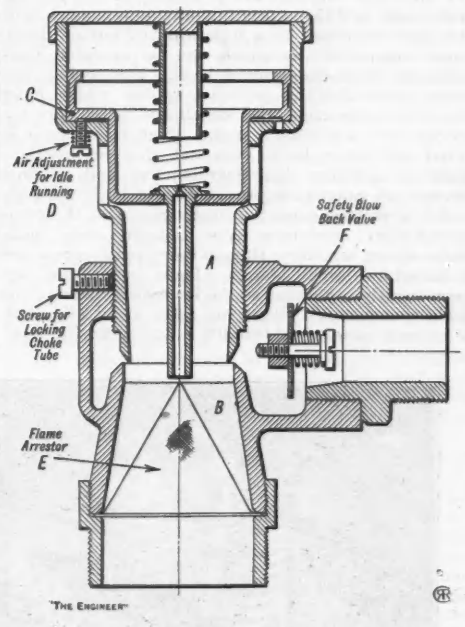
A continuous hot plate surmounts the range for general roasting and baking, This actually comprises two "Bordo" ovens, one being 24in. and the other 30in. wide inside, each having an inside height of 22in. and depth of 24in. The frying range has two 18in. square pans, each 7in. deep, its overall dimensions being 4ft. wide by 2ft. 8in. deep by 3ft high. One of the boilers is used for the preparation of soups, &c., and the other for cooking vegetables, each having a capacity of 20 gals. The gas heated steamer has a compartment 2ft. high, 18in. wide, and 2ft. deep, and the grilling space on the griller is 27in. wide, 16in. deep, and 9in. high. The 10ft. long vapour heated hot closet and serving counter is divided into two sections, one being used for keeping plates warm, and the other for keeping the prepared meals warm and ready for quick serving.



CANTEEN KITCHEN

Gas Mixing Valve

THE accompanying engraving illustrates a gas mixing valve which has been designed in connection with the conversion of petrol driven vehicles to gas operation. The valve consists of a tapered choke tube (A, B) with the smaller tube capable of vertical adjustment, to allow variation of the amount of gas passing between the ends of the two tubes. The upper part of the movable choke tube embodies a differential cylinder, the smaller diameter of which is provided with air inlet ports and the larger with a closely fitting piston (C), the back of which is put into communication with the lower end of the choke tube by a small pipe. On the engine induction stroke, the depression of the pressure at the mouth of the choke tube results in a reduction of pressure above the piston. The rise of this piston varies with the engine speed, thus preserving a correct air and gas mixture. A small screw (D) is provided for idle-running adjustment. To meet the requirements of the Ministry of Transport regulations a flame arrestor



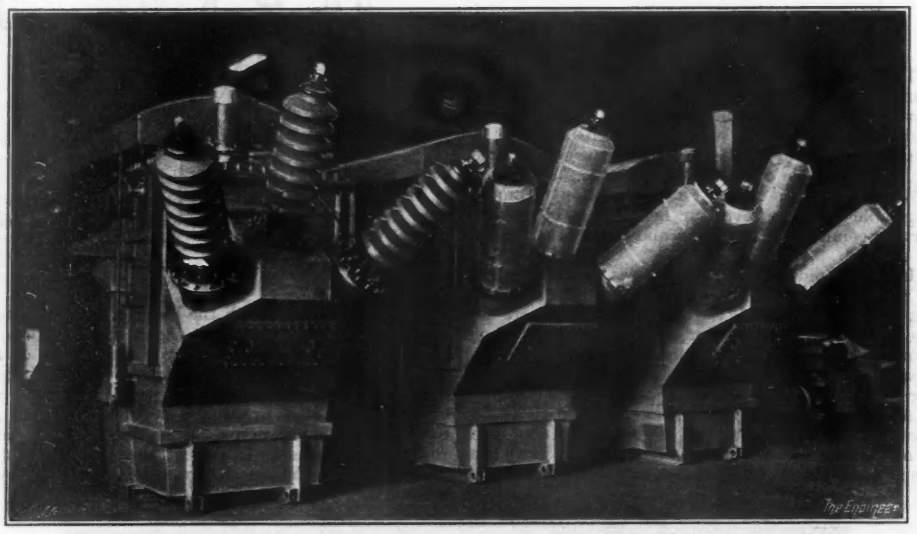
GAS MIXING VALVE

(E) consisting of a cone-shaped gauze is fixed between the gas mixer outlet and the induction manifold. In some cases, as an extra safeguard, a safety blow-back valve (F) is fitted in the valve inlet. The valve has, we are informed, proved itself satisfactory for all sizes of engines up to about 100 H.P.

An alternative arrangement consists of a combined mixing valve and low-pressure reducing valve cast in one body for use in low-pressure gas systems. As a refinement the movable choke tube can be made remotely adjustable by means of a Bowden wire cable. For abnormally heavy engine loads this feature, it is stated, is desirable. The valve was originally designed at the Research Laboratory of the City of Birmingham Gas Department, and is manufactured by Bellis and Morcom, Ltd., Birmingham.

Transformers for the C.E.B.

FIVE large transformers have recently been supplied by the British Electric Transformer Company, Ltd., to the Central Electricity Board. They are three-phase, 50 cycle units with a capacity of 30,000 kVA. Their no-load ratio is 132,000/33,000 volts star/delta connected. The design of these transformers is in accordance with BSS. 171/1936. The transformers are of the 5-limb core type. On the HV windings tappings are provided for $\pm 2{\cdot}86$ per cent., and $\pm 7{\cdot}15$ per cent. voltage variation, and they are connected to a 5-position off-circuit linear type tapping switch which can be operated conveniently from the ground level. For cooling the units, there are two air-blast coolers which have forced oil circulation, and which are bolted directly to one end of the main tank. Each transformer is fitted with an explosion vent and silica-gel breather, while in addition dial thermometers and window pattern oil gauges are provided. On both the high and low voltage sides the bushings are of the compound-filled condenser type. Above each main tank cover, auxiliary three-phase transformers are mounted in small tanks. These auxiliaries are permanently connected to the low voltage side of the main transformers. They are rated at 30 kVA with a no-load ratio of 33,000/400 volts, delta/star connected. On these transformers there are no tappings. Each auxiliary transformer tank is provided with a conservator, an explosion vent and a silica-gel breather. The engraving shows three of these units awaiting delivery at the British Electric Transformer Company's Hayes works.



30,000 kVA TRANSFORMERS FOR THE C.E.B.

Track-Layer Tractor

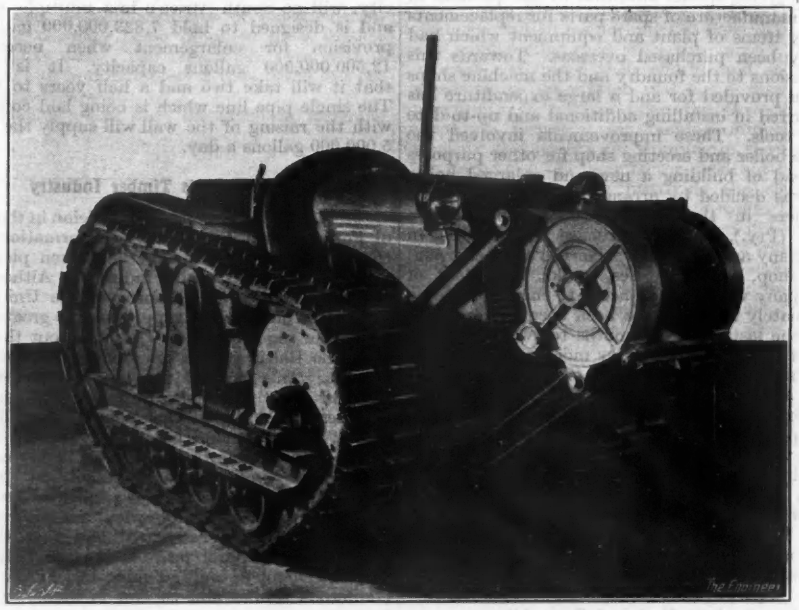
IN the accompanying engraving we reproduce a photograph of a new track-layer tractor manufactured by David Brown Tractors, Ltd., of Meltham, near Huddersfield. At the front of the tractor is mounted a power-driven winch, which has obvious military uses and is also designed for timber working and for the extrication of bogged vehicles.

The tractor is built up from units mounted on a specially designed sub-frame. These units comprise the engine, gear-box, differential, radiator, tanks, and so forth assembled as a major unit, and a special spur-gear final reduction unit mounted on the sub-frame, the front of the major unit being attached at a single point to one of the cross-members. Standard structural steel sections are used for the construction of the sub-frame.

From the differential the drive is taken through the spur reduction gearing mentioned above to the rear track hubs, upon which are mounted brake drums of large diameter, forming in addition the steering medium. Fitted to the periphery are sprocket plates between which are mounted a number of rollers for transmitting the drive to the track shoes, on the inverted-tooth chain-drive principle. The tracks provide a runway for four bogie rollers per side; adjustment for the tracks is effected by moving the idler sprockets at the front of the tractor, recoil springs being furnished to provide a shock absorbing medium when irregular ground is being traversed. Independent hand levers control the brakes on each driving hub, thereby effecting the steering of the vehicle. These levers are mounted so as to be within easy reach of the driver.

Power for driving the tractor and operating the winch is supplied by an overhead valve petrol engine, which, with a compression ratio of 5½ to 1, develops 28 B.H.P. at a speed of 1400 r.p.m. A governor is arranged to limit the speed to either 1400 r.p.m. or 2500 r.p.m. The transmission is through a 10in. single dry-plate clutch, provided with ball bearing withdrawal gear, to the combined four-speed, reverse, and differential unit. The road speeds at the lower governed engine speed are 1·2, 1·75, 3·58, and 5·1 m.p.h. in the four respective forward gears, and 0·8 m.p.h. in reverse gear. By opening the throttle to the higher governed speed, the road speeds are, of course, increased correspondingly.

The winch drive is taken from a power take-off shaft on the gear-box through a chain drive and a pair of bevel gears to a jackshaft, driving the winch through a pair of spur gears. The reduction ratio is such that a cable speed of 20ft. per minute is obtained, which is, we are assured, sufficiently low to avoid cable snatching occurring. When operating at this speed, the winch exerts, it is claimed, a minimum cable pull of 15,000 lb.



TRACK-LAYER TRACTOR

Pneumatic Roofs for Army Huts

A NEW type of roof has been approved by the War Office for use in the camps now being built for the militia. It is made of hollow precast concrete units, and has been evolved by Concrete, Ltd., of Leeds and London. The cavities in the precast units are formed by the pneumatic-core method, which is probably well known to our readers.

The advantages claimed for the roof over the type at present specified are its cheapness, and the speed with which it can be erected owing to its extreme simplicity. The "Bison" roof, as it is called, is the result of extensive experiment carried out over several months at the firm's works in Leeds, Hounslow, and Birmingham. The roof has been designed for spans of 19ft., 24ft., and 28ft., as well as for composite roofs of these spans with valley gutters. The roof is formed by two sloping "Bison" slabs which butt together at the apex, and thrust against the gutter beam at the foot. The beams are tied by rods at 12ft. centres. We are informed that the maximum clear space is given below the roof, and that the soffit is smooth and ready to take lime-whitening.

50,000-Volt D.C. Transmission

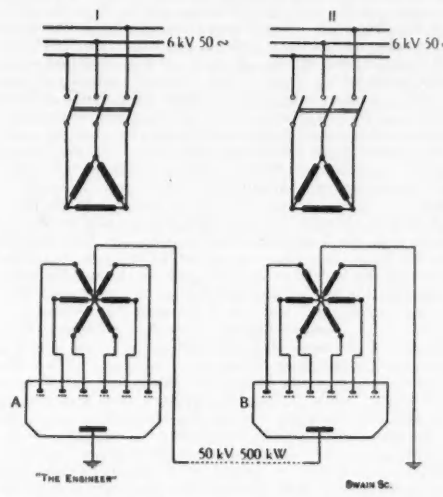
THE use of high tension D.C. for the transmission of power over long distances has been advocated by certain engineers for many years. Inductance and capacity effects which become troublesome, when very great distances are involved, are eliminated and wattless current does not have to be compensated at various points along the line. The cost of the line for a given load has also been shown to be less than that of a three-phase wire. These and other well-known advantages, with which we scarcely need deal, make the scheme attractive when power has to be sent over very many miles. The Thury constant current system with series connected generators is the only D.C. transmission system that has been put to practical use. Since the current is constant the line losses are also constant, but the system does not lend itself to interconnection with existing A.C. networks.

With the advent of high-power mercury arc rectifiers, or mutators, as they are sometimes called, attention has been directed to constant voltage D.C. transmission. An experimental equipment built according to this system, with 50-kV. mutators was shown by Brown Boveri and Co., at the Swiss National exhibition. Although a pressure of 50-kV. is not high enough for the transmission of large quantities of power over long distances, the experimental plant marks an interesting development. The A.C. current is converted into D.C. on the site of power generation and at the end of the transmission line it is converted again into three-phase current for power distribution. Voltage regulation at the receiving end is obtained by on-load tap changing switches on the transformers and by grid control of the mutators. D.C. is only used for power transmission while power generation and distribution are by A.C. which has well-known advantages, especially as regards voltage conversion for numerous consumers.

Existing three-phase power stations, it is pointed out, could be connected to this system for power transmission, the consumers remaining on the existing A.C. distribution systems. As controlled mutators allow of reversing the power flow it is possible to exchange power between different three-phase generating plants thus reversing the coupling of different systems. The wattless current for the network supplied has to be provided by synchronous machines which govern the frequency, since no wattless current can be transmitted over the D.C. line. The advantages of D.C. are most marked when cables are used for transmission because the electrical stress is reduced. Tests

show that mutators for operating at 50kV. can be built for a current of 400 amperes representing an output of 20,000 kilowatts and higher voltages are contemplated.

For the experiment at the Swiss National exhibition, the Zurich electricity works gave its whole-hearted support by placing a transmission line at the disposal of Brown Boveri and Co. A load of 500 kilowatts was transmitted at 50kV. from the Wettingen power station near Baden, to the exhibition in Zurich over a distance of 30 km. A simplified diagram taken from the *Brown Boveri Review* of the connections used for the transmitting and receiving plant is shown below. The A.C.-D.C. mutator set in the Wettingen power house was connected to the generator bus-bars through circuit breakers and disconnecting switches. This set converted the three-phase power at 6kV. into D.C. at 50kV. for direct transmission to Zurich. The transmission line used was really the insulated earth conductor of the existing 50kV. three-phase transmission line which changed over to a cable in the Zurich area and then became a single pole overhead line again in the last section before the exhibition. High voltage D.C. was there converted back to three-phase current at 6kV. and delivered to the



I. Wettingen Power Station. A. A.C.—D.C. Mutator.
II. National Exhibition. B. D.C.—A.C. Mutator.

CONNECTIONS FOR D.C. TRANSMISSION

distribution system of the Zurich electricity works. This conversion took place in a D.C.–A.C. mutator set in the exhibition sub-station. The convertor unit was connected to the 6kV. bus-bars of the sub-station through an air-blast high-speed circuit breaker and a compressed-air operated three-pole disconnecting switch. The earth served as a return conductor and the ordinary service earthing of the power house served as an earth electrode for one of the mutator sets and the rails of the tramway system in Zurich for the other earth connection.

Both mutator sets were of the same design and apart from the control circuits had simple connections. Each unit comprised the mutator with its accessories, a main transformer and a breaker for the A.C. side, the breaker having primary current and thermal relays to protect the set from abnormally high overloads. There was an earthed switch-board panel to accommodate various service switches and measuring instruments and behind it was a highly insulated panel containing the control apparatus. The D.C.–A.C. mutator had been placed in the sub-station and care taken to make it easy to supervise.

The new design of high voltage mutator used on that installation differed considerably from that of former types. For the blocking voltages existing between counter anodes, special anode bushings were developed. At present Brown Boveri and Co. have a complete mutator in service working at a pressure of 60kV., and it is the intention of the company to proceed with the development of units for still higher pressures. When putting the plant into operation the air-blast high-speed circuit breaker of the D.C.–A.C. mutator in the sub-station is closed and by closing the breakers at the other end the A.C.–D.C. mutator is put under voltage which is raised by grid control until the current attains the desired value. A remote control device also enables the latter mutator to be controlled from the switch-board panel in the sub-station. On account of the short distance covered, short-circuits on the transmission line are cleared at the sending end by the immediate action of grid control. A breakdown of the grid control apparatus results in the operation of the protective relay and the tripping of the breaker associated with the set. But the simplifications made possible on this last plant can scarcely be claimed for longer transmission distances which are contemplated in the future.

ITALIAN COLLIERY DISASTER.—A gas explosion in a coal-mine in the Arsa region of Italy has resulted in the death of 46 miners, and it is feared that about 50 more may have lost their lives.

A Modern Coating Machine

THE remarkable strides made by the Canadian newsprint industry during the past two decades has been fostered chiefly by the extensive rise in the amount of newspaper advertising and the inability of the United States mills and forests to keep step with it. During this development, the industry, with the very real aid provided by the paper machine builders has made notable mechanical progress, particularly in efficiency and cost of production. The fine paper industry, however, has not, during this period, experienced anything like the same increased demand for its products. While the mills have kept pace with modern improvements and methods, there has been little incentive for the building of new mills.

With the coated paper industry, the situation is even less favourable from a production standpoint. Tonnage has receded and the technical improvements in methods and materials have, until recently, been comparatively minor. It speaks well for the courage of the executives of Provincial Paper, Limited, as well as their faith in the Canadian coated paper industry, when, in the face of the comparative inactivity of the business they saw fit to install the very latest and modern coating equipment in their plant at Georgetown, Ontario.

A few years ago, Carl Merrill, a heating engineer of Portland, Maine, saw possibilities of greater speed in coating operations if the customary festoon line could be eliminated. He developed a flat, high-temperature and high-speed dryer. About the same time, the S. D. Warren Paper Company was developing the so-called air-brush, which they hoped would overcome the other drawback to bigger speed coating, namely, vibrating brushes. It is the combination of these two pieces of equipment, which allows for greatly increased speed with no sacrifice in quality, that Provincial Paper, after considerable investigation, decided to install.

The backstand of the coater in this plant holds the expiring roll of " raw stock " as well as the new roll to be started, and is so constructed that the splice connecting the two can be made without stopping—a so-called flying splice or paster. The sheet then passes over an idler and a driven roll and then over the colour roll, which consists of a metal roll revolving at a comparatively slow speed in a pan containing the coating mix to be applied. This roll carries up an excess of colour, which the sheet wipes off. The sheet is then led around the brush roll where the air-brush blows off the excess colour and spreads the remainder into an even film. The weight of coat is governed by the pressure of air into the air-brush which in turn governs the air velocity at the nozzle. The sheet then travels up over the suction apron, a perforated endless rubber belt carrying the sheet by vacuum induced by an auxiliary fan. The apron provides the principal drive of the sheet through the coater.

THE DRYER

Almost immediately after leaving the apron, the sheet is fed into the dryer and is carried through by a conveyor made up of sticks set approximately 1ft. apart on a pair of endless chains. The dryer shell is approximately 200ft. long—the longest dryer of this type ever installed for single coating. The length was necessary owing to the use of 8 lb. exhaust steam, but 100 lb. steam has also been provided for use in special cases. For heating the dryer is divided into four sections, each provided with a fan, a set of fin-type heaters and a by-pass. The first two sections each have three heaters and the last two each have two, with space for a third. Each of the ten heaters is separately connected to both exhaust and high-pressure steam.

Almost complete recirculation of the heating air is possible owing to the high temperature, which varies between 200 and 300 deg. Fah., depending on the pressure of steam used. The air is pulled out of the dryer below the travelling sheet and delivered downward on top of the sheet through a system of internal ducts. Owing to the fact that the temperature of the drying sheet cannot exceed the wet-bulb temperature of the air, drying temperatures of 300 deg. Fah. and higher are not only safe but quite practicable.

The entire dryer shell is supported fairly high up so that, except where the heating units are placed, there is walking clearance below. Alternating current motors drive the four fans, and these are controlled by push-buttons on the control panel at the dry end of the machine. The entire shell and heater units are insulated with a 2in. spun-rock-wool blanket, covered with two plaster coats and heavy duck. With this type of dryer there is no particular necessity for a positive feed of fresh air, as the conveyor sticks, where they emerge from and re-enter the shell at either end produce sufficient " spill " for the purpose. There is, however, a stack ventilator at each end of the shell which tends to produce a slight negative pressure inside. These are not necessary in all cases, however, and usually are installed for the operators' comfort, rather than for any effect they may have on the drying operation.

WINDING EQUIPMENT

Coating dryers, either festoon or flat, differ from paper-machine dryers in that the drying is " slack." In order to obtain a tight sheet for winding, a hold-back is used immediately following the dryer. An improved type is used for the Provincial machine. It consists essentially of a driven drum, around which the sheet travels, being held against the drum by means of tapes. Between the dryer and the hold-back the sheet hangs on a controlled loop. Following the hold-back, there is a Pope reel of usual design but with minor modifications required for handling coated paper. The hold-back, as its name implies, allows for putting varying tension on the sheet going to the reel.

AUXILIARY EQUIPMENT

There are five sections to the whole machine, each driven by a direct-current gear motor through a chain drive. These are as follows, starting from the coater end : The coater rolls, apron, dryer conveyor, hold-back, and reel. Each motor has its own rheostat for adjusting the draw of the sheet between the sections. The different drives do not, however, need to be tied in as in the case of a paper machine drive as the sheet is not as tender and there is more opportunity for slip. In fact, slip is quite necessary in the dryer section, as if the sheet, while being dried, was not allowed to change its position over the conveyor sticks, so-called " stick-marks " would be apt to develop. The D.C. motor driving the hold-back is actually a generator (feeding back into the line) as soon as the sheet reaches the reel, as then the hold-back is a brake being pulled by the sheet. The winding tension is adjusted by the rheostats connected with the motors driving the reel and hold-back.

The prime mover for the entire machine is a motor-generator set and the machine speed is governed by voltage control at the generator. The main panel holding the rheostat for this speed control is set at the dry end close to the reel. This panel also carries the ammeter and voltmeter for the generator, the ammeters for the sectional motors, the rheostat for motors on the hold-back and reel, and the push-buttons operating the four fans. The main control of the machine is therefore with the operators at the dry end, although there is an emergency stop-button at the wet end as well.

The amount of air required for the air brush is rather large, considering also the pressure at which it is used. Specially designed rotary turbo-compressors are used for this purpose, there being two which are connected in series and each is driven by a separate motor. One or both may be required, depending on the class of work to be done. In the Provincial installation the compressors, together with the motor generator set and main power panel, are located in the basement below the machine.

Mention has already been made of the change from a slack sheet to a tight one by means of the hold-back. Between the dryer and the hold-back the sheet still hangs in a slack loop. Owing to the fact that there is no definite tie-in between the section drives, either electrically or mechanically, it would be almost impossible to keep this loop at a constant position, and it would either drop to the floor or rise to the position of a tight sheet. This condition is avoided by the installation of a small rider, resting on top of the loop which actuates, by means of compressed air, a rheostat, which in turn governs the speed of the hold-back and reel, to keep the loop at practically a constant height. Photo-electric cells may be, and have been, used to accomplish the same result.

It is desirable with coated paper, as with most other papers, to be able to control the moisture content. While this is difficult with a festoon dryer, it is comparatively easy with a flat dryer of controlled speed, provided an instrument is available to indicate the dryness of the sheet. The Rogers condition indicator has been found well suited to this purpose, and while it does not necessarily indicate moisture directly, it does indicate a condition which can be duplicated for any given grade. The control rests with the speed of the machine ; for example, should the indicator show that the sheet is too dry, the machine is speeded up until the desired condition is indicated. The instrument is quite sensitive and is being found useful on paper machines as well as coaters.

The overall length of the machine is approximately 250ft., and it is designed to coat a web 8ft. wide at speeds from 150 to 700ft. per minute. The maximum speed depends on a number of variables, some of which are : steam pressure, weight and width of web, weight and composition of coat. Production, likewise, depends on all these as well as the number of changes in any given period. It is difficult, therefore, to give any figure for capacity, but similar machines have produced as much as 50 tons of paper coated on one side, in 24 hours.

OPPOSITION TO THE LAKE ERIE-OHIO RIVER CANAL.—The United States Interstate Commerce Commission has published a report on its investigation into the proposed Lake Erie-Ohio River Canal which it is estimated would cost 240 million dollars to build. In the conclusion it is pointed out that a large volume of traffic, at least 56 million tons a year, and probably considerably more, would be affected and the gross revenue loss of the railroads would be about 35 million dollars and possibly more ; that the railroads could ill afford, now or in the future, to lose revenue on such an amount of traffic, and that they have ample line and terminal capacity to carry any traffic that is likely to develop for many years to come.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer.

A New Scrap Order

A new Scrap Order has been issued by the Minister of Supply entitled the Iron and Steel (No. 7) (Scrap) Order, 1940, which will take effect as from March 5th. It fixes new prices for iron and steel scrap and supersedes the Control of Iron and Steel (No. 5) (Scrap) Order, 1939. The effect of the Order is to increase the main range of maximum prices of iron and steel scrap by from 5s. to 10s. per ton. Adjustments to meet changing conditions have led to larger increases in a few cases. In substance the scope of the Order remains unchanged, but there have been certain additions to the specifications of the material covered by the maximum price provisions. The Direction (No. 1) under the Order issued with it repeats the provisions of the similar Direction under the previous Order exempting the sale and purchase of scrap from the requirement of licence except for certain special types. Copies of the Order may be purchased from H.M. Stationery Office or through any bookseller.

The Pig Iron Market

Conditions in the pig iron market have not materially altered during the past week or two. Generally speaking, consumers are receiving sufficient supplies to enable them to maintain a good rate of operation, but this is made possible by the careful supervision of distribution by the Control. In the case of most descriptions of pig iron there are no stocks either at the producing or consuming works. The Control, however, is concentrating upon the equitable distribution of the available supplies and is averse to consumers building up reserves which might lead to other works going short. This policy is generally accepted as the correct one, although naturally there are some users who would feel happier if they were able to lay in a store of pig iron. In the foundry market, the demand is inclined to be irregular, but considerable quantities are passing into consumption. Production, although on a good scale, could be increased if a bigger output were required. The light castings foundries, which are the largest users of high phosphoric pig iron, are not well employed, although there is a gradual improvement in this respect as an increasing number are being employed upon work arising from the war. The demand for low phosphoric foundry iron seems to be rather more than current production can satisfy as it is used chiefly by engineering foundries which are employed on work of national importance. It is possible that the production of this class of iron may be increased in the near future. On the North-East Coast, Cleveland foundry iron is not being made, and local foundries are being supplied with Midland brands. The producing plants of the Midlands are all busily employed, and large tonnages are passing into consumption. Consumers are receiving good supplies, and although there was some difficulty with regard to deliveries owing to the bad weather in the first part of January, this has now been overcome. The Scottish foundry iron trade is rather slow as the light casting works are not well employed. It is expected, however, that they will receive more Government contracts in the future, and this may lead to a heavier demand for ordinary foundry qualities. Business in hematite iron is particularly active, and there seems little in the way of stocks to draw from. Production is at a high level, and it is probable that it will be increased this month. The scarcity of scrap has led to an increased demand for both hematite and basic. The latter description is in short supply, notwithstanding important arrivals from abroad. Additional imports are expected during the next few weeks, and this should allay, to some extent, the steel makers' anxieties.

The Midlands and South Wales

The steelworks in the Midlands are doing their best to meet the enormous demand for steel, but are gradually slipping behind in the struggle. Delivery dates are lengthening, and most of the makers are reluctant to accept fresh business, an attitude which can be easily understood since their order books provide for full working for the next seven or eight months. Practically all the production is on work which comes within the priority categories and ordinary business has little chance of being placed. The constructional engineering industry is taking large quantities of joists and sections, and most of these firms have important jobs in hand which will keep them well occupied for many months. There is, therefore, little likelihood of any relaxation in the pressure to obtain supplies of structural steel, particularly as the shipyards which for months past have been taking heavy tonnages, are likely to need still larger supplies in the future as the result of the Admiralty's naval and mercantile shipbuilding programme. The heavy engineering industry is also a big consumer of various descriptions of steel, and is almost entirely engaged upon Government work. It is difficult to place orders for plates, especially heavy and medium descriptions, and in the majority of cases delivery cannot be promised in less than six or seven months. Not only are heavy tonnages passing to the shipyards, but the locomotive builders are busy, and the tank makers are booked up for many weeks. The rerolling industry is now operating at a good rate as supplies of billets have come to hand with greater freedom during the past week or two. In some instances, however, deliveries have not been sufficient to meet the requirements of the works. Nevertheless, output is at a high rate, and the arrears consequent upon the slow working during January are being quickly made up. In South Wales the steelworks are operating at capacity, and in spite of their large production are falling behind with deliveries. All departments of the industry are experiencing an insistent demand. Although there was a slight recession in the overseas request for tinplates, this proved to be only temporary, and great activity now prevails. The home requirements continue large principally for Government purposes. In addition to the heavy demands for steel from the constructional and general engineers, the ship repairing yards are taking good quantities.

The North-East Coast and Yorkshire

The steel industry on the North-East Coast is working at as near to capacity as circumstances will permit, and this intensive effort is responsible for a huge output of steel which is passing into immediate consumption. The vast bulk of the production is for Government work, but lately it has been noticeable that licences for ordinary work have been given out with rather more freedom. The pressure by consumers to obtain supplies is unrelaxed and is applied to every section of the industry. Raw materials are now reaching the works on a more satisfactory scale, with the exception of iron and steel scrap, which is still scarce. The search for supplies of the latter material is one of the preoccupations of the steelmakers and it is hoped that considerable quantities of imported scrap will shortly make an appearance in this country. The stringency has led to a greater demand for basic pig iron, with the result that some scarcity has developed. The scrap position is more complicated as some consumers who normally use the better qualities of scrap are now contenting themselves with lower grades, and this is creating a shortage of this description. The distribution of finished steel, however, has been carried out in a way which has avoided any great inconvenience to consumers, although naturally there has been delay in the completion of contracts. The production of structural steel in the shape of joists and sections has reached a large proportion, and that these have been immediately absorbed by the consuming industries is an indication of the magnitude of the war effort. The constructional engineers have a great deal of work on hand in the way of new building jobs, and extensions to premises, and as a consequence there is an insatiable demand for all sizes of joists and sections. The requirements of the shipyards, also, are not only on a huge scale but are increasing week by week, and in view of the programme of new building of naval and merchant ships the demand from this quarter is likely to strengthen rather than the reverse. The plate mills have orders in hand, sufficient to keep them employed for several months, and there is no relaxation in the pressure to obtain supplies of sheets. The Yorkshire steel industry is fully occupied, and works are gradually extending the periods required for delivery. In a number of cases, makers are reluctant to accept new business owing to the already congested state of their order books. There has been no diminution in the demand for basic steel. The pressure upon the makers of billets and sheet bars increases, but some relief has been afforded to the situation in this department by imports from abroad. The demand for acid carbon billets is growing and many makers now require seven or eight months to execute a new order. There is continual pressure to obtain supplies of alloy and special steels and great activity rules at the works producing stainless steel. The rerollers are well supplied with orders, and lately some improvement has been noticeable in the supplies of billets in this industry.

Copper and Tin

The improvement in the world copper market noted in our last week's issue developed considerable strength before it died away. In one day the American producers are reported to have sold 60,000 tons to domestic consumers at a price of 11·50c. After this it is not surprising that the demand declined, although the quotation remained unchanged. This movement has placed the producers in a strong position, as although consumers in the United States had absorbed a good proportion of the copper ordered early in the year, the new buying has again comfortably filled the makers' books. In fact it is generally believed that consumers are now covered until the end of May, and buying on a large scale is not expected to develop until some time in that month. The improvement in the American domestic quotation led to a sympathetic advance in the export price which stands at 11·75c. Neutral buying has not been particularly active of late although Switzerland has been responsible for some enquiry. Buying by other export markets has been quiet. The publication of the American export figures shows that Russia bought 23,753 tons in January which is considerably above the normal Russian imports, and it is suggested that some of this copper is finding its way to Germany via Vladivostock. Japan was the second largest importer with 11,254 tons. January was a good month for the American consuming industry and it is understood that no less than 82,500 short tons of copper were consumed. The stocks in consumers' hands at the end of January were calculated at 245,500 tons, and the orders in hand at 180,000 tons, leaving surplus stocks of about 65,000 tons. . . . The rise in price of tin which followed the announcement of the reduction in the export quota by the International Tin Committee to 80 per cent. of the standard tonnage has continued, with the result that the action of the Committee has aroused a certain amount of criticism. There is no lack of tin at the moment, but it is suggested that the cut, which amounts practically to a third of the output, will have the effect of forcing values to too high a level. On the other hand it is thought that the possibility that tin sold to the United States has been re-sold to Russia for trans-shipment to Germany may have had something to do with the decision of the Committee. It is obvious that a reduction of exports will limit the amount of tin available for re-sale. The Government of the United States is understood to have advised the New York Exchange that they disapprove of this class of business, and in consequence the Exchange now requires a guarantee that the metal sold shall not be exported. It is also pointed out that the rise in prices should assist Great Britain's exchange position, as licences for the export of fair quantities have been given out lately. Mr. W. H. Gartsen's statistics give the total visible supply on February 29th as 23,865 tons compared with 24,798 tons at the end of January, a decrease of 933 tons. The supplies during February totalled 11,863 tons compared with 18,022 tons in January, and the deliveries were 12,796 tons, against 18,244 tons. Of the latter the United States took 6600 tons, and Great Britain 990 tons.

Lead and Spelter

The lead position so far as this country is concerned is satisfactory. Whilst consumption is at a high level and is said to be tending to increase, supplies are adequate to meet the demand. Distribution by the Control appears satisfactory, but there does not seem to be any surplus for any but orders arising from Government requirements. Large quantities are being absorbed by the cable and battery makers, but some other sections of the consuming trades are not so well supplied with orders, particularly those which normally rely upon the building trades to take a considerable proportion of their output. A certain amount of lead is being released to meet ordinary commercial needs and generally speaking consumers have little cause for complaint. In the world market irregular conditions prevail, and whilst some countries have more than sufficient lead to meet consumers' requirements, others are short of the metal. In Holland, for instance, there is little prompt lead available for the market; in the United States, business has been active, and the price has been raised to 5.25c. per lb. This movement did not come as a surprise to the market since it has been known for some time that the producers were well sold, and had not been pressing to obtain new business. . . . The consumption of spelter in Great Britain continues to increase and apparently the metal arriving here is rapidly taken up by users. Practically all sections of the industries using spelter are busily employed upon Government work. The brassmakers are particularly busy and provide a good outlet for the metal, whilst the galvanisers are responsible for a heavy consumption. The die castings makers also have large Government orders in hand, and lately have bought with some freedom. At times a scarcity of high grade spelter has been noticeable, but this has been only temporary and, in spite of the heavy demands, there are good supplies of G.O.B. qualities available. An active business developed recently in the United States and the sales in one day are reported to have exceeded 7000 short tons. The producers raised their quotation to 5·70c. East St. Louis. Stocks in America have fallen to a low level, and this may have accounted for the sharp buying movement, since American manufacturers are apt to develop nerves if stocks show signs of becoming depleted.

Non-Ferrous Metal Prices

The London Metal Exchange official average prices for tin in February show a substantial rise over the January figures. The average price for cash tin advanced by £2 1s. 7d., and for three months by £2 6s., the settlement price being £2 2s. 8d. above the January average. The maximum prices for copper, lead, and spelter fixed by the Controller of Non-Ferrous Metals are also given in the statement issued by the Metal Exchange, which is as follows:—

STANDARD TIN ...	Cash (Mean) £242 19s. 7½d.
	3 Months (Mean) £242 15s. 1¾d.
	Settlement (Mean) £243 0s. 2½d.

The following prices for copper, lead, and spelter are the maximum prices fixed by the Controller of Non-Ferrous Metals:—

STANDARD COPPER—	£	s.	d.	
Electrolytic Copper ...	62	0	0	delivered buyers' premises
Electrolytic Wire Bars...	62	0	0	" " "
Best Selected Copper ...	60	10	0	" " "
Lead—Good Soft Pig ...	25	0	0	" " "
(Foreign)				(duty paid)
Spelter—G.O.B. ...	25	15	0	delivered buyers' premises
(Foreign)				(duty paid)

A NEW STEEL MAKING PROCESS.—A new steel making process, known as "Pluramelt," has been announced in the United States by the Allegheny Steel Corporation. In its most popular form it consists of a metal having a stainless steel surface on an ordinary carbon steel. It is produced in a special type of electric arc melting furnace in which all of the composition materials and a small part of the low cost materials are melted and integrally joined. According to the *Iron Age*, the furnace proper is radically different from the conventional type of electric furnace in that the functions of steel making and the mould are combined. In this way special steels are melted and united to the low cost steels in ingot form. It is said that the process produces single ingots of two or more compositions integrally bound together and it is possible to change the composition within certain limits during the melting operation. The description says that the materials which have been successfully produced are:—Allegheny metal 18–8S (low carbon, 18 per cent. chromium, 8 per cent. nickel); the same with columbium, molybdenum or both; low carbon, 13 per cent. chromium steel; and various tool steel compositions for the alloy portion and low carbon and carbon molybdenum steels for the base portion. Extensive tests on samples of the new material have failed to disturb the bond between two component metals.

French Engineering Notes

(From our own Correspondent in Paris)

Road and Rail Transport

THE regulations governing public road haulage under the co-ordination plan were already working satisfactorily when they had necessarily to be suspended during the period of hostilities. Lorries and other vehicles were requisitioned and supplies of gas, oil, and petrol were rationed, except for military use. Road hauliers can now only operate within the limits of their respective departments, and long-distance transport is reserved for the railways, with some exceptions. Plans for organising the country's transport services under war conditions were based on the assumption that all vehicles not engaged on national service should run on home-produced substitutes for gas, oil, and petrol. Restrictions imposed on petrol driven lorries were removed from those equipped to run on suction gas, nor would they be liable to requisition, and their owners were granted privileges for haulage within departments and could be authorised to carry goods over long distances. Relief from taxation is another inducement to owners to convert their lorries to suction gas equipment. For a change of this kind to be immediately effective lorry owners must have confidence and the means of converting their vehicles at reasonable cost, which is only possible by means of a practical and extensive organisation that is still in a committee stage. Had the National Railway Company been able to deal satisfactorily with long distance traffic the question of road haulage would not be occupying so much attention as it is doing now. But the railways, under the military requisition system, find it difficult to deal normally with a goods traffic that has grown considerably with the restrictions imposed on road hauliers. While preference in transport must be given to military needs it is becoming increasingly urgent to provide facilities for production and distribution. The S.N.C.F. is certainly obtaining supplies of locomotives and goods wagons from Great Britain, but they are insufficient to enable the company to deal satisfactorily with the whole of the traffic, and the road must therefore come to the help of the railway. The Minister of Public Works has consequently instituted a commission to go into the question of modifying existing arrangements for the carriage of goods in order to obtain a maximum efficiency in national transport. The commission is composed of five representatives of State services controlling the transport of goods; two representatives of the National Railway Company; two representatives of chambers of commerce; and three other members will represent the national federation of road hauliers, the Superior Council of Transports, and the motor-car industry.

The State and Industry

During hostilities industry is controlled by the State almost as completely as in totalitarian countries. It is organised by one man with the sole object of winning the war. Since the mobilisation, industry has been adapted to that one end, and no one complains of the way in which remarkable results have been achieved. Still, memories of the failure of Socialist State control are too fresh to avoid apprehension that the present experience may, when the necessity for it no longer exists, be continued in a less complete form that will restrict the initiative and authority of manufacturers. Fortunately, a reassuring pronouncement has been made by Monsieur Daniel Serruys, High Commissioner of National Economy, who makes a clear distinction between war and peace conditions. The whole industrial resources of the country are at present concentrated on the successful prosecution of the war, which means not only the production of armaments and an elimination of waste, but also the development of foreign trade and the creation of new industries for the utilisation of home natural resources. After the war, this concentrated energy and the expenditure of thousands of millions of francs on a work of destruction must be diverted to productive works, particularly the carrying out of vast undertakings in different parts of the world. The partial flooding of the Sahara desert as a means of giving fertility to the remainder and the construction of a Trans-Saharan railway were mentioned by Monsieur Serruys, who also referred to opportunities that awaited engineers in the construction of roads and railways in Asia and the carrying out of public works in South America and elsewhere. Collectivism and Communism must, he said, be eliminated from a post war organisation. The work can only be done by individual effort and initiative. It is a task for human beings, and it is upon them that a nation rises to greatness. In view of the position occupied by Monsieur Serruys in directing the State war economy his ideas of a post war organisation imply that the State will go no farther than is necessary to help private enterprise and give confidence to capital, without which enterprise fails.

The Rochelle-Pallice Mole

The first ship to use the new mole between La Pallice and the Ile of Ré was one from Antwerp which recently embarked 200 Belgian passengers for the Belgian Congo who had travelled overland. The construction of the mole was begun in 1931, but owing to errors in data regarding the rock foundation the work was suspended for a long time. Meanwhile the construction of the viaduct with two decks, one for the railway to La Rochelle and Paris and the other for a roadway and footways, was continued straight for 950 yards, and then curved round to the mole. The mole is in a channel having a depth of 94ft. at low water level. The distance between the mainland and the Ile de Ré is about two miles, and the shelter allows of ships mooring safely alongside the mole in all weathers. La Pallice is the maritime port of La Rochelle, which claims to offer advantages over Bordeaux for dealing with traffic to and from Central and South America as well as the west coast of Africa. La Rochelle has a shorter railway route to Paris and the convenience of a sheltered and safe channel for all ships between La Pallice and the Ile de Ré. La Pallice has, in fact, become a rival of Le Verdon, where ocean liners call to land and embark passengers to and from Bordeaux.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

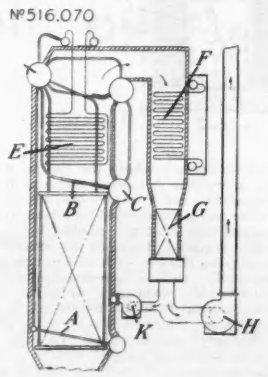
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

STEAM GENERATORS

516,070. June 20th, 1938.—IMPROVEMENTS RELATING TO STEAM GENERATING AND SUPERHEATING INSTALLATIONS, AND TO THE METHOD OF OPERATING THE SAME, Marine and Locomotive Superheaters, Ltd., formerly known as the Superheater Company, Ltd., and Leonard Clement Southcott, both of Bush House, Aldwych, London, W.C.2.

In the accompanying drawing is a diagrammatic illustration of a boiler and superheater plant incorporating an embodiment of the present invention. The generating surface of the boiler is mainly constituted by the water tubes lining the walls of the furnace chamber, the slag screen A and the tubes B leading across the top of the furnace chamber from a water drum C to a steam and water drum. Above the furnace chamber is a convectively heated superheater E and the gases, after flowing over the superheater elements, are utilised to heat a reheater F, economiser G, and an air heater. After leaving the air heater the gases are drawn by the main boiler induced draught fan H

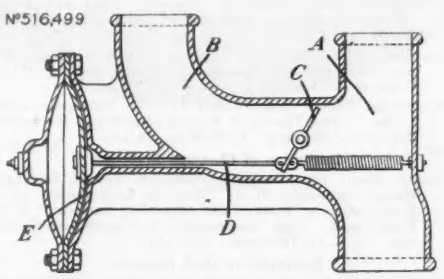


and delivered into the chimney duct. A fan K draws gases through a branch from the chimney duct and delivers them into the furnace chamber. The quantity of gas returned to the furnace chamber is regulated as necessary, by varying the speed of the fan, in order to obtain the desired increase in steam temperature over that which normally would be obtained by the usual rate of firing. In the operation of the plant the transfer of heat from the fresh combustion gases in the furnace chamber to the water tubes and the slag screen will be reduced, as the furnace temperature is reduced due to the admission of the returned products of combustion, but the volume or weight of gases available to pass over the superheater elements will be materially increased, resulting in the required steam temperature being obtained without an excessive gas temperature at the superheater elements. Further, in consequence of the increased volume of gases flowing over the reheater, a higher reheat temperature will be obtained.—*December 21st, 1939.*

INTERNAL COMBUSTION ENGINES

516,499. July 14th, 1938.—CONTROL OF LIQUID COOLING SYSTEMS OF INTERNAL COMBUSTION ENGINES, Saunders Valve Company, Ltd., Buckingham House, 19, Palace Street, London, S.W.1, and Philip Keith Saunders, 42, Drayton Street, Wolverhampton.

In order to render the thermostatic control of an internal combustion engine substantially independent of atmospheric pressure, according to this invention the cooling system is sealed and a valve, controlling the flow to a bye-passed radiator, is operated by a diaphragm one side of which is open to the pressure in the cooling system and the other side to a sealed chamber. An embodiment of the invention is illustrated diagrammatically in the accompanying drawing. The T piece shown is fitted in the cooling system of the engine with

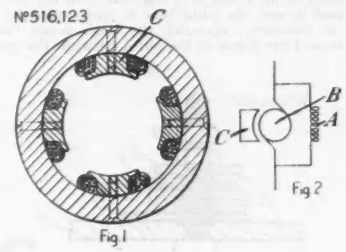


the passage A connected in the usual radiator bye-pass and the branch piece B connected to the radiator inlet. Flow of cooling liquid down this branch is controlled by the butterfly valve C which is loaded by the spring towards the closed position. The valve is connected by the wire D to a diaphragm E clamped between an extension on the side of the branch and a rigid plate. The space between the diaphragm and the plate is evacuated or filled with the vapour of a volatile liquid. It will be understood that the valve does not make a completely tight joint but in the closed position substantially prevents any flow of cooling liquid through the radiator. The branch is consequently under the same pressure as the rest of the cooling system. The cooling system is sealed. As the temperature of the cooling liquid rises therefore the pressure rises, and acting on the diaphragm opens the valve and thus admits cooling liquid to the radiator.—*January 3rd, 1940.*

DYNAMOS AND MOTORS

516,123. June 18th, 1938.—ELECTRIC GENERATORS PARTICULARLY FOR INTERNAL COMBUSTION ENGINE IGNITION, Harold Edward William West, of "Jeruel," Parkside Lane, Allestree, Derby, and Rolls-Royce, Ltd., at Nightingale Road, Derby.

This invention is particularly suitable for electrical generators driven by internal combustion engines for supplying electric current to ignite the combustible mixture in the engine cylinders. The object is a form of electric generator in which the voltage rise with increase of armature speed will be maintained within the required limits. The stator consists of a cylinder of a steel having 35 per cent. of cobalt or of a nickle-aluminium-steel each of which has a high coercive force when magnetised. The cylinder is magnetised to produce four poles at points 90 deg.

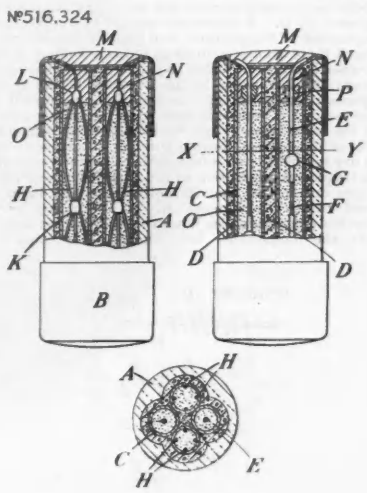


apart, and at each of these points there is attached by screws shown soft iron shoes. Around these shoes is wound a field winding which, as shown at A in Fig. 2, forms a shunt winding connected directly across the rotor or armature B. By suitably proportioning the coil windings of this shunt winding it is possible to arrange that at high generator speeds the opposing field will operate to reduce the voltage of the generator without permanently reducing the main flux produced by the permanent magnet, but at lower speed the reduction produced will be smaller and immaterial. By this means the voltage of the generator may be kept under control at high speeds while at the same time securing at lower speeds sufficient voltage to serve for the ignition purposes of an internal combustion engine driving the generator.—*December 22nd, 1939.*

ELECTRICAL APPLIANCES

516,324. July 15th, 1938.—FUSES FOR THE PROTECTION OF ELECTRIC CIRCUITS, Callender's Cable and Construction Company, Ltd., of Hamilton House, Victoria Embankment, London, E.C.4, Leslie Giddens Brazier, and Alfred Whitley Metcalf, both of the company's address.

A fuse constructed in accordance with the present invention comprises two groups of fusible elements having different operating characteristics. The fuse is of the cartridge type and comprises a cylindrical barrel A made of insulating material, closed at its ends by metal end caps B, fixed to the barrel by cement. The bore of the barrel has a number of semi-circular recesses, each of which receives a glass tube C, the tubes being fixed in position within the barrel by cement D. Each tube, of which there are four, contains a fusible element. Two of these elements comprise silver wires E of circular cross-section having centrally disposed waist portions F of comparatively short length with globules G of low melting point metal attached to the wires adjacent to the waists. The area of cross-section of the end portions of each wire is large as compared with that of the waist. The other elements comprise a number of silver wires H of circular cross-section brought together at places midway of their lengths and joined at those places by globules K of low melting point metal. The wires H are not waisted

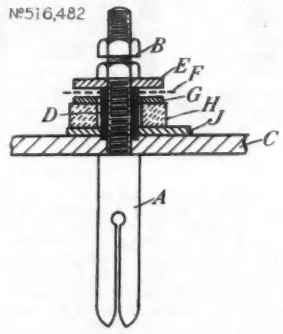


as are the wires E but are of uniform cross-section and at their ends the wires H are brought together and are joined by globules L of low melting point metal to which is also attached a short length of copper wire. The ends of the wires H projecting beyond the globules L are twisted around the copper wires so that the latter are in parallel with the ends of the silver wires H. The wires H and the copper wires are taken out through the end of the tubes C and the wires E are also taken out through the ends of the tubes, all the wires being connected in parallel at their ends by soldering metal M which is run into the concaved ends of the caps B. The ends of the tubes C are closed by cement plugs N and the spaces between the plugs are filled with sand or other arc-quenching material O. The wires E are taken out through glass beads P. The fusible elements consisting of the wires E, waists F and globules G have the characteristic of high rupturing performance and the fusible elements consisting of the wires H and globules K and L have the characteristic of discrimination. In the construction shown, each group consists of a pair of elements. By varying the number of the elements in the two groups, the characteristics of the fuse may be varied to meet particular conditions. By employing elements having different characteristics it becomes possible to produce a fuse which combines in desired proportions the characteristics of both kinds of elements.—*December 29th, 1939.*

516,482. June 28th, 1938.—MEANS FOR PROTECTING ELECTRICAL APPARATUS AGAINST SURGES AND EXCESSIVE VOLTAGES, The General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C.2, and Leonard William Barsdorf of the same address.

This invention relates to means for protecting electrical

apparatus, for example, portable electrical apparatus such as refrigerators, vacuum cleaners, and the like against surges and excessive voltages due to lightning and other causes. Protective means for guarding against surges and excessive voltages normally comprise spark gaps arranged to break down on the occurrence of unsafe conditions and to connect the electrical circuit in which the surge or excessive voltage occurs to earth. The three-pin plug, one live pin A of which is shown, is similar in construction to the ordinary standard three-pin plug, the three pins, that is the earth pin (not shown) and two live pins, being mounted on an insulating plug base C. The shanks of the pins project through the base in the normal manner, and are provided with terminals as that at B for the connection thereto of the supply and earth leads to a portable electric apparatus such as a refrigerator, vacuum cleaner or the like. A removable insulating cover (not shown) of standard pattern is provided for enclosing the terminals of the three pins. The shank of the live pin A and, of course, the other line pin between the terminal B and the plug base is surrounded by a short bush D of insulating material, the bush being clamped in position around the shank of the pin A between the base C and

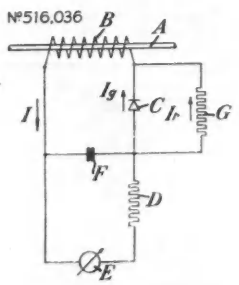


a metal washer E. Around this bush D are placed a perforated disc F of insulating material adjacent to the metal washer E, a second metal washer G between which and the first metal washer E the perforated disc F lies, an apertured block H of carborundum and between this block H, and the base a strip J of metal connecting the side of the block H remote from the spark gap formed by the perforated disc F and the metal washers E and G with the earth pin of the plug. Thus between the live pin A of the plug and the earth pin there is arranged a spark gap connected in series with a high resistance. In the operation of the device, the plug is wired up in the normal manner and may then be plugged into the socket adapted to provide the power for the electrical apparatus associated with the plug. If, now, any surges or excessive voltages occur in the supply leads to the apparatus, due to lightning or other causes, the spark gaps in the plug break down, the surges or excessive voltages are earthed and the apparatus is protected against damage.—*January 3rd*, 1940.

MEASURING AND TESTING INSTRUMENTS

516,036. July 8th, 1938.—MEASURING ARRANGEMENTS FOR HIGH FREQUENCY CURRENTS, Siemens und Halske Aktien-Gesellschaft.

This invention relates to measuring arrangements for high frequency electric currents and is concerned with arrangements for measuring high-frequency currents in which the current to be measured is fed through a dry rectifier to a direct current measuring instrument. In order to measure the high-frequency current in a conductor A, a single-conductor current transformer is provided in the usual manner, the secondary winding of which is designated by B. A measuring rectifier C, a series resistance D independent of temperature, and a direct current measuring instrument E are connected in series to the secondary winding B. A condenser F is also provided to shunt the alternating current component flowing owing to the capacity of the rectifier C. A compensating or balancing resistance G is connected in parallel with the rectifier C, this resistance being responsive to temperature in the same sense as the rectifier, but independent of the strength of the current flowing through it. It is known that normal dry rectifiers have considerable capacitative conductivity at high frequency in addition to the ohmic conductivity dependent upon current, so that, in addition to the direct current measured by the instrument E, an alternating current of considerable magnitude also flows through the rectifier. If, for example, the temperature falls, the ohmic resistance of the

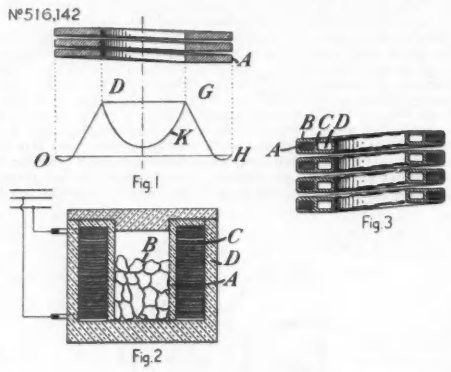


rectifier increases, while the capacitative resistance remains unchanged. Consequently, the current measured by the instrument E decreases. If the resistance G is connected in parallel with the rectifier C, a part I_g of the total alternating current I flows through the rectifier and another part I_r flows through the compensating resistance. As the resistance G increases in value with decreasing temperature, the value of the alternating current component of the rectifier current I_g increases relatively to the value of the alternating current flowing through the resistance G because the capacity of the rectifier does not alter with temperature. However, the increase in the alternating current component of I_g also produces an increase in the direct current component of the rectifier. If the compensating resistance is suitably dimensioned, the reduction in the direct current due to the decrease in the rectifier temperature can be more or less accurately compensated by the increase in the direct current owing to the increase in value of the resistance G so that the direct current measured by the instrument E is not appreciably altered by variations in temperature. This compensation is assisted by reason of the fact that the increase in the value of the compensating resistence G, the resistance D remaining constant, causes an increase in the proportion of the total potential across the rectifier, this, in turn, reducing the ohmic resistance of the rectifier owing to the known dependence of this resistance upon potential.—*December 20th*, 1939.

FURNACES

516,142. June 21st, 1938.—INDUCTIVE HEATING AT LOW FREQUENCY, Alexander Frederic Fekete, of 212*f*, Hampden Way, London, N.14.

This invention relates to inductive heating at low frequency, that is to say 100 cycles per second or less, and is particularly concerned with the provision of apparatus capable of operating efficiently at the frequency of the normal supply mains. It is the object of the invention to make more efficient use of the heat generated in the exciting winding. Referring to Fig. 1, a helically wound coil A carrying a current has developed in the conductor thereof a flux which is represented by the parts O D and G H of the curve. Thus the flux rises from zero at the outside to a maximum at the inside. If there is no conducting material within the coil, the flux is constant over this space as indicated by the straight line between points D and G. When conducting material is introduced into the space the flux is distributed approximately according to a parabolic law as indicated by the curve K, the flux being a minimum at the centre. The material to be heated is preferably arranged near to the inner surface of the conductor of a coil since the eddy current in this part of the conductor is much greater than



that near the outer surface where the flux is low. In Fig. 2 there is shown a crucible A having material B to be heated within it. An exciting coil C is provided around the crucible. The outside of the coil is surrounded by a heat insulating casing D. It is arranged that heat can readily be transferred from the coil C to the material B within the crucible through the crucible walls whereas the loss of heat through the outer walls of casing D is small. In this case heating of the material B may be arranged to take place partly from the coil C itself and partly from the material B or the crucible A or both acting as eddy current carriers. The coil C may be of electrically conducting or semi-conducting material. In some cases a semi-conductor such as carbon or graphite can be used, for example. The coil is shown connected between two phases of a three phase supply. In Fig. 3 the coil conductor A, which may be solid or liquid, is acommodated within a heat insulating casing B and is separated by a partition C from the material D to be heated which is disposed alongside of the coil conductor and which may be any liquid material to be heated such as water or molten lead for example. Where the conductor of the exciting means is a liquid it is preferably a metallic liquid such as molten lead for example.—*December 22nd*, 1939.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Air Raid Protection Institute

Tuesday, March 12th.—Royal Society of Arts, John Street, Adelphi, W.C.2. "The Factory and A.R.P.," S. A. Mitchell. 8. p.m.

Institution of Automobile Engineers

Tuesday, March 12th.—Coventry Centre. Kings Head Hotel, Coventry. "Modern Applications of Cast Iron in Automobile Construction," E. C. Toghill and R. Dowle. 7 p.m. Luton Centre. George Hotel, Luton. "A Few Odd Notes on Engines," A. Taub. 7.30 p.m.

Wednesday, March 13th.—Manchester Centre. Engineers' Club, Albert Square, Manchester. "Alternative Fuels for C.I. Engines," W. Allen. 7.15 p.m.

Monday, March 18th. Glasgow Centre. Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow. "Exhaust Systems for Four and Six-cylinder Engines," J. C. Morrison. 7.30 p.m.

Tuesday, March 19th.—Birmingham Centre. James Watt Memorial Hall, Birmingham. Symposium on "Deep Drawing Research." 7 p.m.

Wednesday, March 20th.—Leeds Centre. Metropole Hotel, Leeds. "The Theory of Flexible Mountings for Internal Combustion Engines," C. B. Iliffe. 6 p.m.

Institution of Chemical Engineers

To-day, March 8th.—Geological Society's Rooms, Burlington House, Piccadilly, W.1. "Further Experiments on the Evaporation of Water from Saturated Surfaces," R. W. Powell, and "Heat Transmission in Evaporative Condensers," A. K. G. Thomson. 5.15 p.m.

Institution of Civil Engineers

Tuesday, March 19th.—Great George Street, Westminster, S.W.1. "The Sewage Disposal of Delhi," J. A. R. Bromage. 5.30 p.m.

Institution of Electrical Engineers

To-day, March 8th.—N.E. Students' Section. Newe House, Pilgrim Street, Newcastle-upon-Tyne. "Electricity—its Reaction on Human Affairs," J. W. Beauchamp. 7 p.m.

Monday, March 11th.—Savoy Place, Victoria Embankment, W.C.2. Joint Meeting with Inst. C.E. and Inst. Mech. E. "Emergency Repairs, with Special Reference to Welding." 6 p.m.

Friday, March 15th.—Savoy Place, Victoria Embankment, W.C.2. Informal Discussions "Cathode-Ray and Duddell Type Oscillographs," J. T. MacGregor Morris, and "What are the Practical Limits of Error in A.C. House Service Meters and in Sub-Standard Watt Meters?" A. J. Pitt. 6 p.m.

Institution of Engineers-in-Charge

Wednesday, March 13th.—St. Bride Institute, Bride Lane, Fleet Street, E.C.4. "Paints, Varnishes, and their Ingredients," A. E. Robinson. 7 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tuesday, March 19th.—39, Elmbank Crescent, Glasgow, C.2. "A Modern Approach to Building Technique," A. Miller. 6.30 p.m.

Tuesday, March 26th.—39, Elmbank Crescent, Glasgow. "Modern Steam Propelling Units and their Possibilities for Cargo Steamers," J. B. O. Sneeden. 6.30 p.m.

Institute of Fuel

Thursday, March 14th.—Connaught Rooms, Great Queen Street, Kingsway, W.C.2. "Regenerative Feed Heating in Industrial Power Plants," A. F. Webber. 6 p.m.

Institution of Mechanical Engineers

Friday, March 15th.—Storey's Gate, Westminster, S.W.1. Lowe Gray Lecture, "Fifty Years of Marine Engineering," A. L. Mellanby. 6 p.m.

Institution of Naval Architects

Wednesday, March 13th.—Royal Society of Arts, John Street, Adelphi, W.C.2. Annual Meeting.

Institution of Production Engineers

Tuesday, March 12th.—Birmingham Graduates. James Watt Memorial Institute, Birmingham. "Modern Fabrication by Arc Welding," H. W. Hawkins. 7 p.m.

Saturday, March 16th.—Yorkshire Section. Hotel Metropole, Leeds. "Progress in Machine Tool Design," R. C. Fenton. 2.30 p.m.

Manchester Association of Engineers

To-day, March 8th.—Grand Hotel (Jubilee Suite), Aytoun Street, Manchester. Dinner and Dance. 7 for 7.30 p.m.

Newcomen Society

Wednesday, March 13th.—Institution of Civil Engineers, Great George Street, S.W.1. "Electrical Invention and Re-Invention," W. T. O'Dea, and "Amedee Bollee—Pioneer of Mechanical Road Locomotion," J. R. Nichols. 2.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, March 8th.—Mining Institute, Newcastle-upon-Tyne. "Mean Pitch Determination of Variable Pitch Propeller," E.V. Telfer. 6 p.m.

Wednesday, March 13th.—Student Section. Bolbec Hall, Newcastle-upon-Tyne. "Governing and Regulating of Land Turbines," P. J. Daglish. 6.45 p.m.

Royal Institution of Great Britain

To-day, March 8th.—21, Albemarle Street, W.1. "Experiments from the Researches of Sir James Dewar," Sir William Bragg. 5 p.m.

Wednesday, March 13th.—21, Albemarle Street, W.1. "X-ray Optics," W. L. Bragg. 5.15 p.m.

Royal Society of Arts

Wednesday, March 13th.—John Adam Street, Adelphi, W.C.2. "Science and the Divining Rod," J. C. Maby. 2.30 p.m.

Wolverhampton and District Engineering Society

Monday, March 11th.—Victoria Hotel, Wolverhampton. "Ventilating and Air Conditioning," E. Leach. 7.30 p.m.

PERSONAL AND BUSINESS ANNOUNCEMENTS

SULZER FRERES S.A., of Winterthur, Switzerland, announces that it has recently disposed of its Ludwigshafen works.

BAKELITE, Ltd., has acquired the works and business of Warerite, Ltd., of Ware, Herts. Warerite, Ltd. has been engaged in the manufacture of synthetic resin laminated sheet materials.

THE BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., Loughborough, has opened new local offices at Daimler House, Wilmslow Road, Rusholme, Manchester, 14. The offices at Haworth Buildings, Cross Street, Manchester, have been vacated.

CALENDARS AND DIARIES

BRITISH TIMKEN, Ltd., Aston, Birmingham. Monthly wall calendar.

A. A. JONES AND SHIPMAN, Ltd., East Park Road, Leicester. Wall calendar giving present, past, and next months.

CATALOGUES

ARNO PENKUHN, 5, Avenue Gardens, London, W.3. Particulars of "Artus" milling cutter spacers of synthetic resin.

GEORGE ANGUS AND CO., Ltd., Newcastle-upon-Tyne. Catalogue No. 76/11/39. "Superangus 'V' section rope drives."

DAVY AND UNITED ENGINEERING COMPANY, Ltd., Sheffield Publication No. 88 descriptive of the principal types of boilers made by the firm.

THE GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, London, W.C.2. Catalogue of Industrial Lighting Fittings and Accessories.

HENRY WIGGIN AND CO., Ltd., Thames House, Millbank, London, S.W.1. Data Book on Nickel and Cobalt Oxides and Salts, Selenium, and Tellurium.

TUNGUM SALES COMPANY, Ltd., Iddesleigh House, Caxton Street, S.W.1. A brochure dealing in detail with Tungum alloy, its composition, forms, uses, working, &c.

BRITISH ALUMINIUM COMPANY, Ltd., Raven Hotel, Castle Street, Shrewsbury. A 200 page book illustrating a wide range of the drawn and extruded sections in which aluminium and light aluminium alloys are produced for various industrial uses.

DAVID BROWN AND SONS (HUDD.), Ltd., Huddersfield. E 341.9 "Heavy Type Helical Gear Drives"; F 487.5 "48 Hour Service," dealing with Radicon worm reducing units, &c.; F 213.1 "The Hob Book," a publication giving definitions of technical terms, design particulars, and detail dimensions, &c.

ERRATUM.—Books Received. "Electrical Timekeeping":—for Spencer-Jones—as author—read F. Hope Jones. Dr. H. Spencer-Jones wrote the Foreword only. See review in THE ENGINEER, February 2nd.